بسم الله الرحمن الرحيم

Palestine Polytechnic University

Technology And Engineering College

Civil Engineering Department

Building Engineering

Graduation Project

"The Structural Design For A Treatment Hotel Project"

Project Team:

Mohammad AL Najjar **Ahmad Abu Sbeih** **Ithar Hamidat**

Supervisor:

Eng . Inas Shweiki

Hebron-Palestine

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In accordance with the recommendation of the project supervisor and acceptance of all examining committee members, this project has been submitted to the Department of Civil Engineering in the College of Engineering in partial fulfillment of the department's requirements for the degree of Bachelor of Building Engineering.

Signature of Project Supervisor **Signature of Department Chairman**

Name…………………………… **Name ………………………………..**

2025

الإهداء

إلهي لا يطيب الليل إلا بشكرك ولا يطيب النهار إلا بطاعتك ولا تطيب اللحظات إلا بذكرك ولا تطيب الآخرة إلا بعفوك ولا تطيب الجنة إلا برؤيتك

الله سبحانه جل في علاه جل جلاله..

إلى من بلغ الرسالة وأدى الأمانة ونصح الأمة إلى نبي الرحمة ونور العالمين، معلم البشرية ومنبع العلم

سيدنا محمد صلى الله عليه وسلم..

إلى من حاكت سعادتي بخيوط منسوجة من قلبها يا بسمة الحياة وسر الوجود يا من كان دعائها سر نجاحي وحنانها بلسم جراحي وركع العطاء أمام قدميها..

أمي الغالية..

إلى من أحمل اسمه بكل فخر ومن استلمت منه قيم الإنسانية وعلمتني ارتقي سلم الحياة بحكمة وصبر ستبقى كلماتك نجوم أهتدي بها اليوم وفي الغد وإلى الأبد يا صاحب القلب الكبير

والدي..

إلى رياحين حياتي يا من تطلعتم إلى نجاحي بنظرات الأمل ورافقتهم منذ أن حملت حقائب صغيرة

أخوتي..

إلى من معهم وبرفقتهم سرت وكانوا على طريق النجاح والخير وأمضيت معهم ذكريات الأخوة

الذين تسكن صورهم وأصواتهم أجمل لحظات الأيام التي عشتها

أصدقائي..

إلى من هم أفضل منا جميعا الذين رووا بدمائهم ثرى فلسطين

كل الشهداء..

إلى من عشقوا الحرية وخاضوا بأمعائهم حربا من اجلك

اهدي هذه الثمرة المتواضعة لك

قدسي..

واخيراً وليس اخراً إلى جميع الأساتذة في دائرة الهندسة المدنية الذين لم يبخلوا بنصائحهم وتوجيهاتهم علينا

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In conclusion, we would like to thank our fathers, mothers, and brothers who had the greatest role in reaching what we have reached, and perhaps we will fulfill their right by achieving their satisfaction.

"The Structural Design For A Treatment Hotel Project"

Project Team:

Mohammad AL Najjar **Ahmad Abu Sbeih** **Ithar Hamidat**

Supervisor:

Eng . Inas Shweiki

ABSTRACT

This project aims to design a therapeutic hotel, which is a very luxurious construction project. The hotel is located in the city of Hebron - Nimra. The land area allocated for the project is 18,500 square meters. The building was designed to occupy an area of 2,580 square meters of the total area of the land, with the remaining area allocated to green spaces and recreational facilities.

Due to the large area of the project, we faced many construction challenges, the most important of which was the distribution of the structural system of columns, bridges, nodes, walls, and foundations, and determining the locations of expansion joints, as this project is characterized by the diversity of architectural design from floor to floor, which posed a challenge in distributing columns and determining Their locations affected the distribution and design of slabs and bridges, so we will resort to using safe and economical solutions, such as choosing the appropriate types of knots for the structural system.

The analysis and design has been done by using structural design programs such as and not limited (SAFE) (ETABS), (Atir), (AutoCAD) and (Excel).

The results obtained lead to the development of an integrated structural design that meets the standards of the ACI-318-19 Structural Design Code, in addition to meeting the owner’s desires and ensuring complete safety. The hotel's architectural aesthetic standards are also taken into account to ensure harmony and visual appeal.

“The Structural Design For A Treatment Hotel Project”

Project Team:

Mohammad AL Najjar **Ahmad Abu Sbeih** **Ithar Hamidat**

Supervisor:

Eng . Inas Shweiki

ABSTRACT

يهدف مشروع التخرج هذا إلى تصميم فندق علاجي، وهو مشروع إنشائي فخم جدا . يقع الفندق في مدينة الخليل – نمره ، تبلغ مساحة الأرض المخصصة للمشروع 18500 متر مربع، حيث تم تصميم المبنى ليشغل مساحة مقدارها 2580 متر مربع من المساحة الكليه للارض ، مع تخصيص المساحة المتبقية للمساحات الخضراء والمرافق الترفيهية

ونظراً لكبر مساحة المشروع واجهنا العديد من التحديات الإنشائية، أهمها توزيع النظام الإنشائي من أعمدة، و جسور، وعقدات، وجدران، وأساسات، وتحديد مواقع فواصل التمدد، حيث إن هذا المشروع يتميز بتنوع التصميم المعماري من طابق الى طابق مما شكل تحديا في توزيع الأعمدة وتحديد مواقعها مما أثر على توزيع وتصميم البلاطات والجسور ، لذلك سوف نلجأ الى استخدام حلول آمنة واقتصادية، مثل اختيار أنواع العقدات المناسبة للنظام الإنشائي .

وسوف يتم التحليل والتصميم باستخدام برامج التصميم الإنشائي مثل (SAFE), (ETABS 21), (Atir 18), (AutoCAD) و برامج أخرى مثل (Excel) .

تؤدي النتائج المستخلصة إلى تطوير تصميم إنشائي متكامل يفي بمعايير كود (ACI-318-19) للتصميم الإنشائي، بالإضافة إلى تلبية رغبات المالك وضمان الأمان الكامل. كما يتم مراعاة المعايير الجمالية المعمارية للفندق لضمان التناغم والجاذبية البصري.

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LIST OF ABBREVIATIONS

- **A_c =** area of concrete section resisting shear transfer.
- **A_s =** area of non-prestressed tension reinforcement.
- **A_s`=** area of non-prestressed compression reinforcement.
- **A_g =** gross area of section.
- **A_v =** area of shear reinforcement within a distance (S).
- **A_t =** area of one leg of a closed stirrup resisting tension within a (S).
- **b =** width of compression face of member.
- **b_w =** web width, or diameter of circular section.
- **C_c =** compression resultant of concrete section.
- **C_s =** compression resultant of compression steel.
- **DL =** dead loads.
- **d =** distance from extreme compression fiber to centroid of tension reinforcement.
- **E_c =** modulus of elasticity of concrete.
- **f_c` =** compression strength of concrete.
- **f_y =** specified yield strength of non-prestressed reinforcement.
- **h =** overall thickness of member.
- **L_n =** length of clear span in long direction of two- way construction measured face-to- face of supports in slabs without beams and face to face of beam or other supports in other cases.
- **LL =** live loads.
- **L_w =** length of wall.
- **M =** bending moment.
- **M_u =** factored moment at section.

- **M_n =** nominal moment.
- **P_n =** nominal axial load.
- **P_u =** factored axial load
- **S =** Spacing of shear in direction parallel to longitudinal reinforcement.
- **V_c** = nominal shear strength provided by concrete.
- **V_n** = nominal shear stress.
- **V_s** = nominal shear strength provided by shear reinforcement.
- **V_u** = factored shear force at section.
- **W_c** = weight of concrete.
- **W** = width of beam or rib.
- **W_u** = factored load per unit area.
- **Φ** = strength reduction factor.
- **ε_c =** compression strain of concrete = 0.003.
- **ε_s =** strain of tension steel**.**
- **$\acute{\varepsilon}_s$ =** strain of compression steel.
- **ρ** = ratio of steel area.

CHAPTER 1

" INTRODUCTION"

1.1 INTRODUCTION.

1.2 PROJECT OBJECTIVES.

1.3 WORK PROCEDURE.

1.4 PROJECT SCOPE.

1.5 PROGRAMS USED IN THE PROJECT.

1.6 TIMETABLE

Figure 1.1 : Expressive Image

1.1 INTRODUCTION

Engineering is the best way to harness natural resources to serve humanity.

In other words, it is the art of applying scientific principles and life experiences to our lives to improve the things we use or the facilities we live in. In general, it is the body that combines the available technical tools, activities and knowledge. It is the professional activity that uses imagination, wisdom and intelligence in the application of science, technology, mathematics and practical experience in order to be able to design, produce and manage processes that suit the needs of mankind.

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 for our health and well-being, so civil engineering in general is the only way to make the world a more suitable and suitable place to live in.

Building engineering in particular is the engineering that takes care of providing the required housing with the required specifications, the required quality, and the resources available to each individual in the community , and it 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, and construction components of buildings and railways.

1.2 PROJECT OBJECTIVES

After completing this project, we hope to achieve the following objectives:

1. Obtaining experience in solving the problems of each project in particular.
2. Improving the ability to choose the appropriate structural system for the project and distributing its structural elements on the plans, taking into account preserving the architectural character.
3. Gaining experience in reaching the best safe and economical design.
4. Using structural design programs and comparing them with theoretical solutions.

1.3 WORK PROCEDURE

To achieve the objectives of the project, the following steps were taken:

1. The architectural study in which the site, building plans and floor heights were studied.
2. Structural planning of the building, in which the type of slab is selected and the location of columns, beams and shear walls is determined, taking into account the architectural design.
3. A structural study in which all structural members are identified and the different loads are indicated
4. Analysis and design of the elements according to the ACI code using software and theoretical solutions.
5. Preparing construction drawings for all the elements in the building.
6. Writing a project where all these stages are presented in detail.

1.4 PROJECT SCOPE

This Project contains the following chapters:

CHAPTER 1: General introduction.

CHAPTER 2: Architectural description of the project.

CHAPTER 3: General description of the structural elements.

CHAPTER 4 : Structural Analysis And Design.

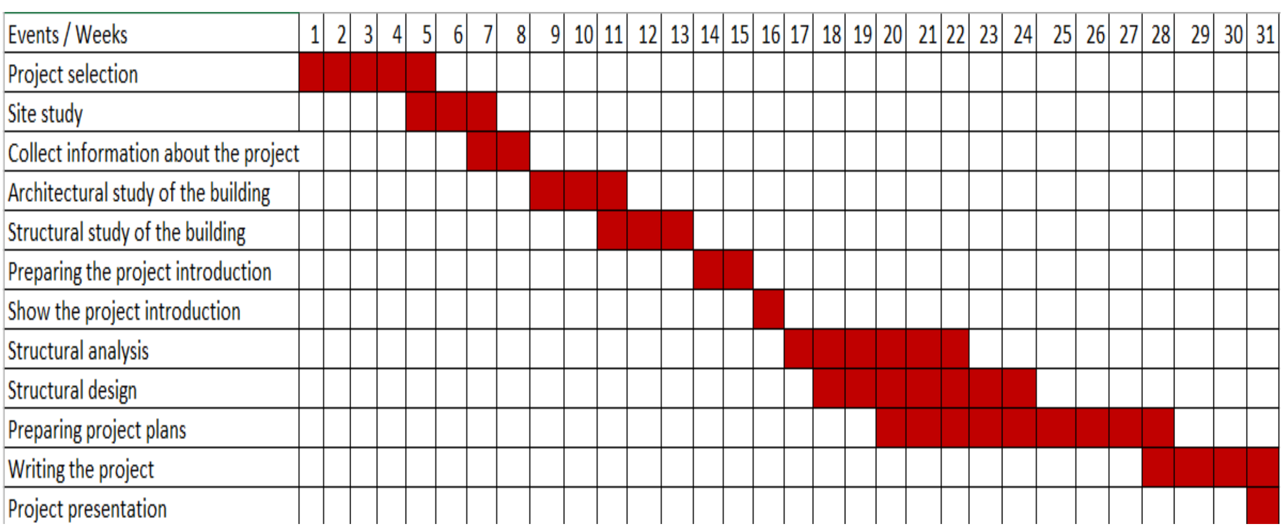
CHAPTER 5 : Recommendations and References.

1.5 PROGRAMS USED IN THE PROJECT

1. Adoption of the American code in the various structural designs (ACI-318-19)
2. Using analysis and structural design programs such as (SAFE) (ETABS), (Atir).
3. Other programs such as Microsoft office Word, Excel.
4. AutoCAD.

1.6 Timetable:

2024-2025 *Table 1.1: Timetable*



CHAPTER 2

" ARCHITECTURAL DESCRIPTION "

2.1 INTRODUCTION.

2.2 GENERAL IDENTIFICATION OF THE PROJECT.

2.3 FLOORS DESCRIPTION.

2.4 ELEVATIONS DESCRIPTION.

Figure2.1: Main Elevation

2.1 INTRODUCTION

Architecture is considered an art, talent, and idea, which derives its fuel from what God has bestowed upon the architect from the talents of beauty. With these talents, he moved from the life of the caves to the best form of luxury, taking advantage of the beauty God gave him of this picturesque nature, and if every art or science has controls and limits, architecture is not subject to any limitation or restriction, as it oscillates between imagination and reality. The result may be buildings of extreme simplicity and beauty.

The design process for any facility or building occurs through several stages until it is completed to the fullest, starting with the architectural design stage. The initial installation of the facilities, achieving the required spaces and dimensions, and in the process lighting, ventilation, movement, mobility, and other functional requirements are also studied.

Architectural designs should be easy to deal with and understand the various events and other things of importance that give a clear view of the project thus it will be possible to locate the columns and other structural elements in the structural design process that aims to determine the dimensions of the structural elements and their characteristics depending on the different loads that are placed on them. Transported through these elements to the foundations and then to the soil.

2.2 GENERAL IDENTIFICATION OF THE PROJECT

This therapeutic hotel is unique in that it specializes in everything related to physical therapy,

Due to the nature of this medical hotel, we have taken into consideration a lot of things so that we can design it structurally.

The building consists of nine floors. the first basement floor , the second basement floor , the ground floor , mezaneen floor this floor contains all the sanitary, electrical and technical installations that serve the building, the first floor , and the floors from the second to the fifth have the same area .

As for the description of the hotel's entrances and exits, they are as follows:

The main entrance is towards the west, where there are four gates close to each other for people to enter and exit through to the building itself (ground floor), and there are two subsidiary entrances with two different gates towards the east for people to enter and exit from the building (ground floor).

As for the entry and exit of cars, they are as follows:

As for the first basement floor, cars enter it from the main entrance of the hotel towards the west. They walk on a paved street located towards the south and enter from a gate located there. Upon exiting, cars exit from a gate located towards the north, then they head to the main western entrance and leave from there.

As for the second basement level, cars enter it just as they enter the first basement floor, but its gate is located below the first gate, and cars can continue driving towards the east and exit from there, or there is no gate located towards the north.

2.3 FLOORS DESCRIPTION

The project consists of nine floors with a total area of 24500 m^2.

2.3.1 Second Basement Floor :

(Level -6.7 m) with an area of 5070 m^2

The second basement floor consists of parking, stairs, elevators and warehouses , as shown in the figure (2.2).

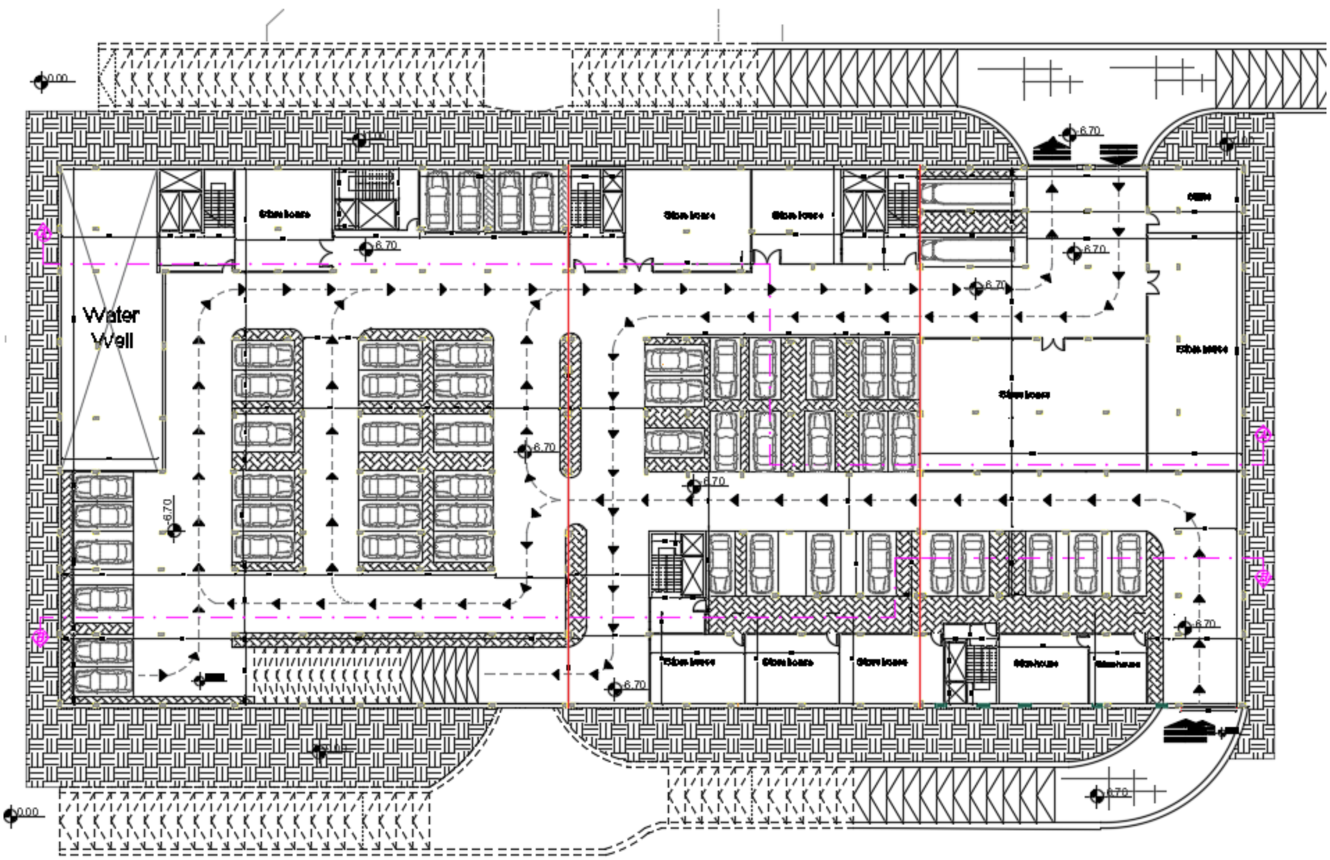


Figure 2.2: Second Basement Floor Plan

2.3.2 First Basement Floor:

(Level -3.2 m) with an area of 5070 m^2

The first basement floor consists of parking, stairs, elevators, rooms, stores, reception, offices, generator, electricity, kitchen, dishwashing area, massage room, sauna, two swimming pools and equipment maintenance , as shown in the figure (2.3)

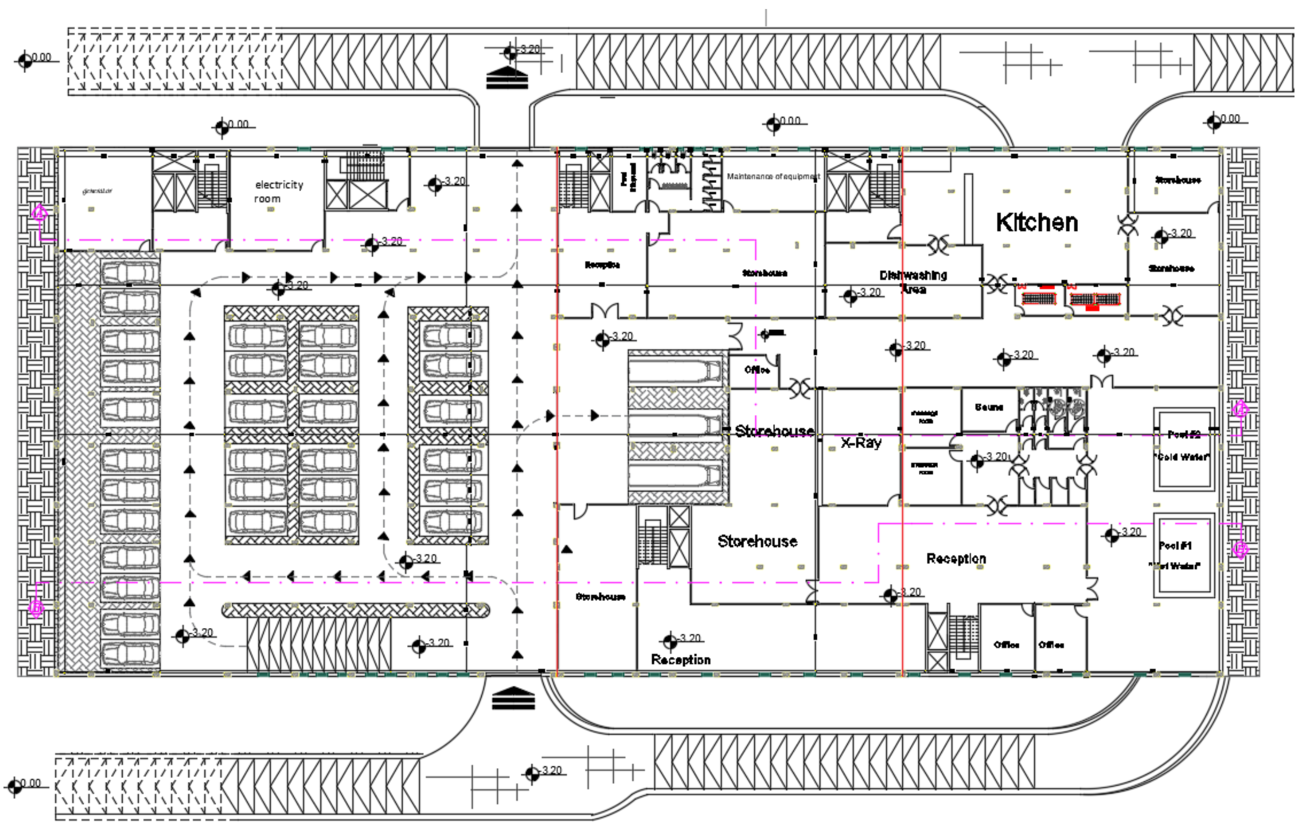


Figure 2.3: first Basement Floor Plan

2.3.3 Ground Floor:

(Level +0.3 m) with an area of 2580 m^2

The ground floor consists reception, a restaurant, a bathroom, a waiting doctor, clinics, a pharmacy, a laboratory, accounting, a cafeteria, and offices, as shown in Figure (2.4).

Next to this floor is a floor called the mezzanine (level + 3.3m) with an area of 2580 m^2 this floor contains all the sanitary, electrical and technical installations that serve the building .

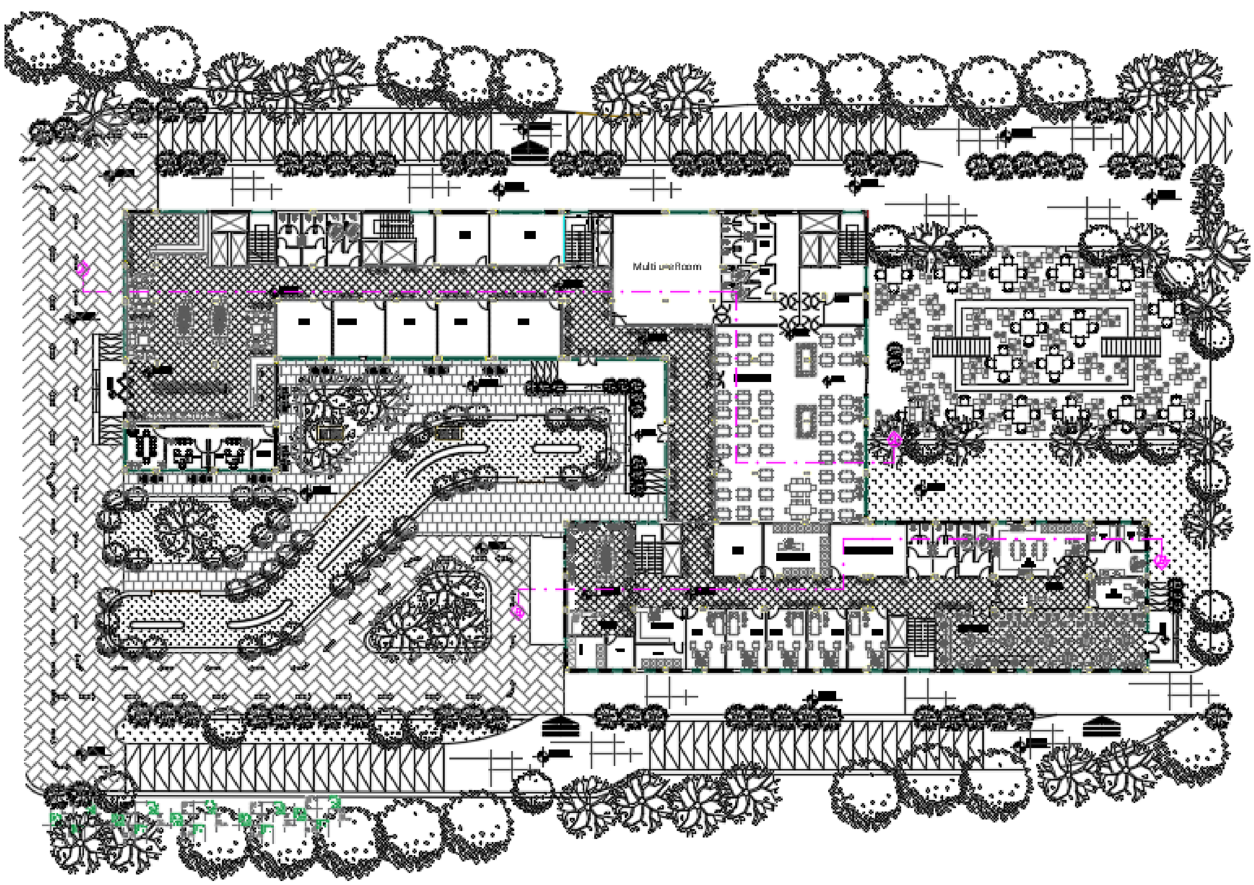


Figure 2.4 : Ground Floor Plan

2.3.4 Mezzanine Floor :

(level + 3.75m) with an area of 2580 m^2

This floor contains all the sanitary, electrical and technical installations that serve the building as shown in Figure (2.5)

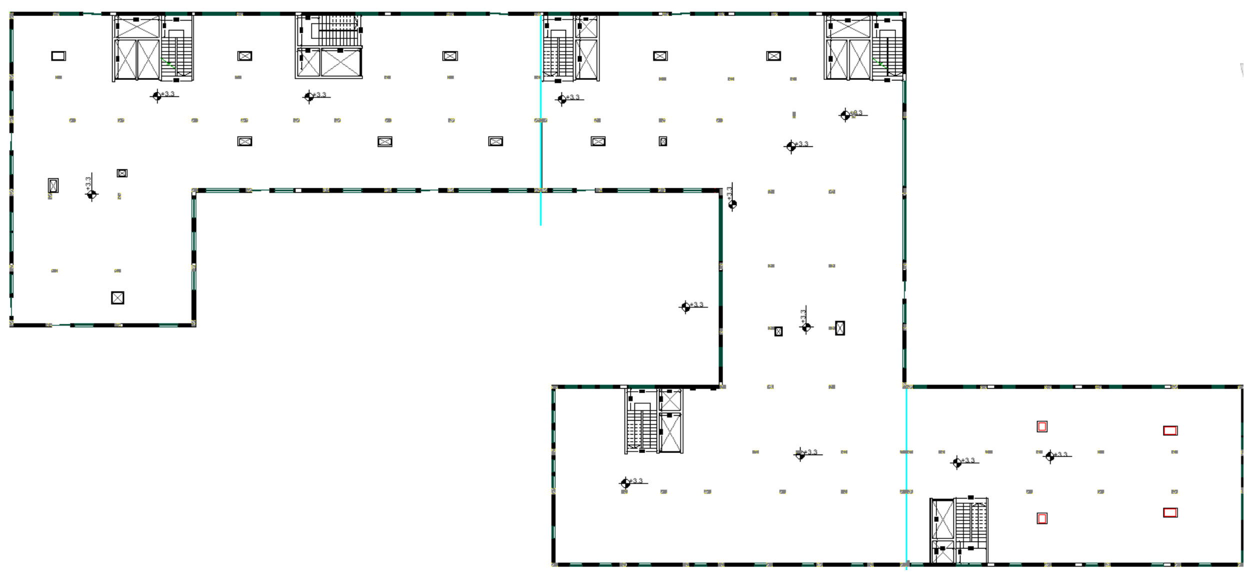


Figure 2.5 : Mezzanine Floor Plan

2.3.5 First Floor:

(Level +5.7 m) with an area of 2580 m^2.

The first floor consists of various bedrooms, a bathroom, a breakfast area, electrotherapy room, short wave therapy room , synthetic needles, herbal remedy , and doctors bed room, as shown in Figure (2.6).

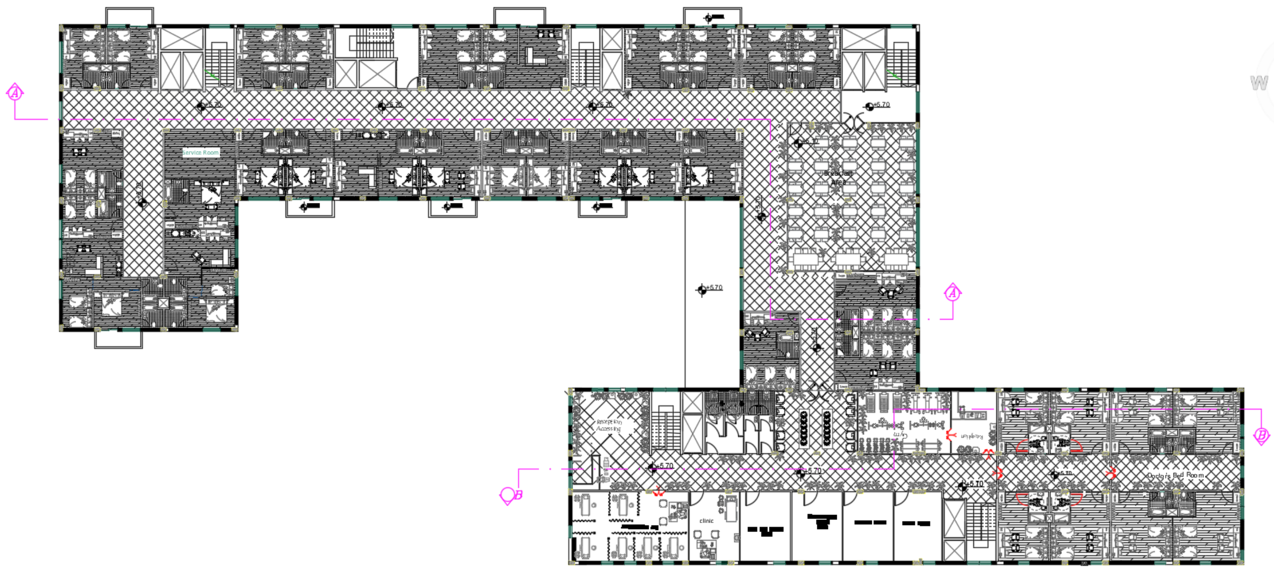


Figure 2.6:First Floor Plan

2.3.6 Second Floor To Five Floor :

Second Floor (Level + 8.85 m) with an area of 1655 m^2.

Third Floor (Level + 12 m) with an area of 1655 m^2.

Fourth Floor (Level + 15.15 m) with an area of 1655 m^2.

Fifth Floor (Level + 18.3 m) with an area of 1655 m^2.

Floors from the second to the fifth have the same area 1655 m2 and have the same uses Various bedrooms with bathrooms, as shown in Figure (2.7).

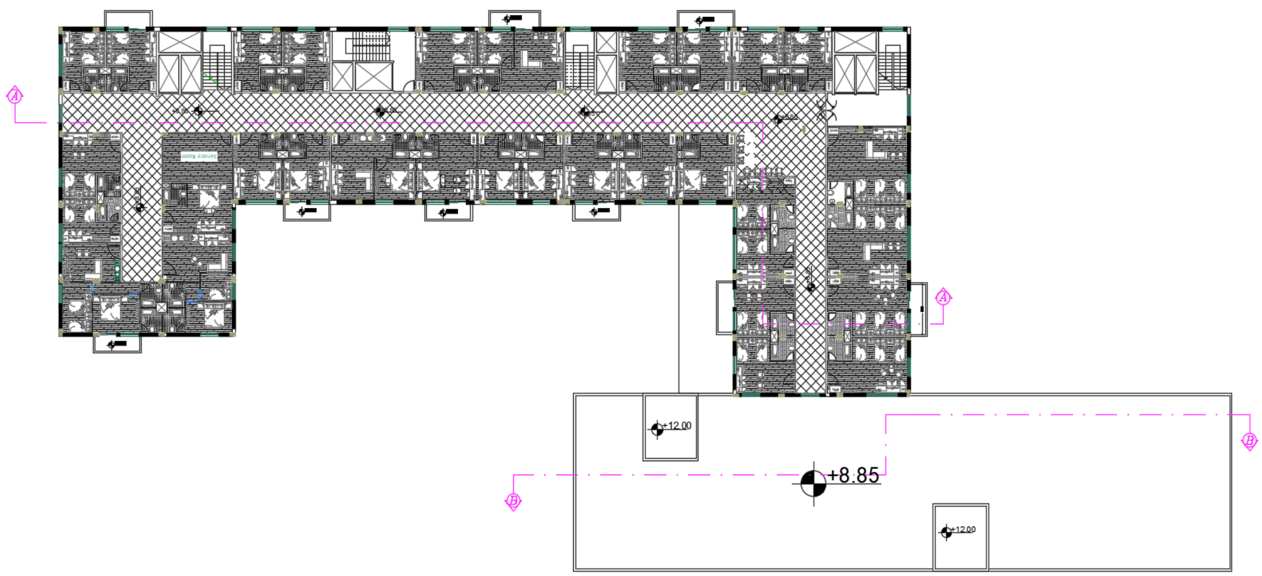


Figure 2.7: Second Floor Plan

2.4 ELEVATIONS DESCRIPTION

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

2.4.1 Northern Elevation:

The northern elevation shows the entrance to the parking lot, clinic windows, patient rooms, the kitchen, , and the electricity room , as shown in Figure (2.8).

Figure 2.8: Northern Elevation

2.4.2 South Elevation:

The southern elevation shows the windows of the clinic rooms , archive room , electrotherapy room, short wave therapy room , synthetic needles, and the herbal remedy , as shown in Figure (2.9).

Figure 2.9: South Elevation

2.4.3 East Elevation:

The eastern elevation shows Storehouses, Ponds room, The hall , Breakfast Area , Patient rooms as shown in Figure (2.10).

Figure 2.10 :East Elevation

2.4.4 West Elevation:

The western elevation shows a rear entrance to the hospital, as shown in Figure (2.11).

Figure 2.11: West Elevation

2.5 Sections :

2.5.1 Section A-A :

Figure 2.12: Section A-A

2.5.2 Section B-B :

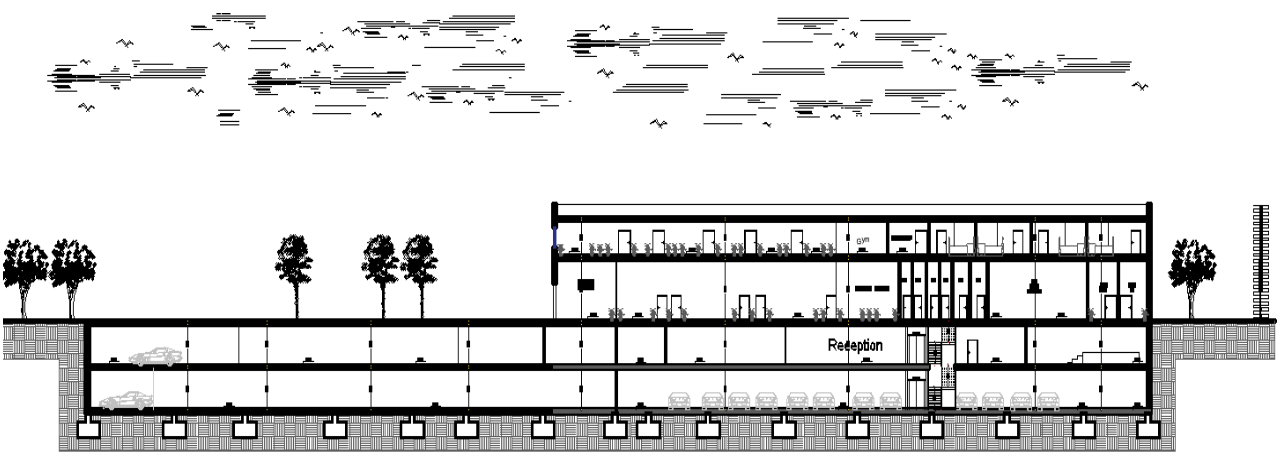


Figure 2.13: Section B-B

CHAPTER 3
“STRUCTURAL DESCRIPTION”

3.1 INTRODUCTION.

3.2 THE AIM OF THE STRUCTURAL DESIGN.

3.3 LOADS ACTING ON THE BUILDING.

3.4 SCIENTIFIC TESTS.

3.5 STRUCTURAL ELEMENTS OF THE BUILDING.

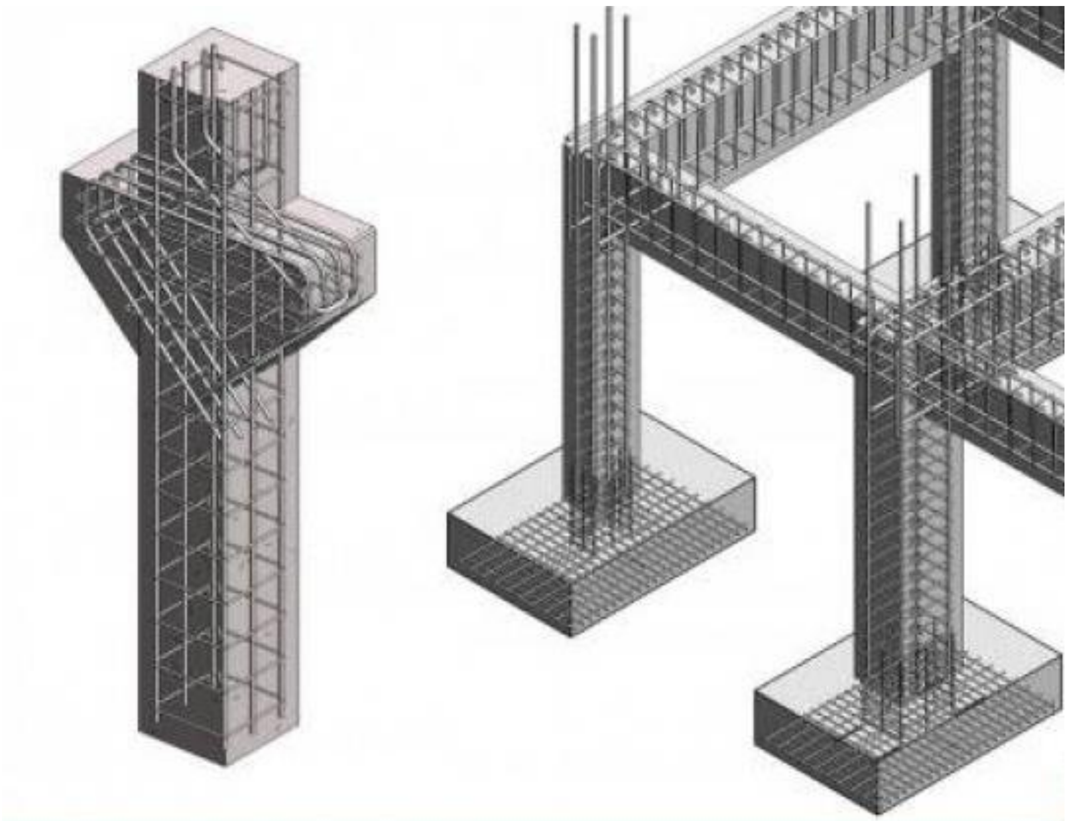


Figure 3.1: Expressive Image

3.1 INTRODUCTION

Structural design is a methodical investigation to get the economical specification of a structure or a structural element to carry the predicted load safely. With the application of structural design, we can obtain the required size, grade, reinforcement, etc. Of structural members to withstand the internal forces calculated from the structural analysis.

If the structure is not designed properly including proper selection of materials and technology or if the structure that we have designed is subjected to excessive load than the specified limit then it will probably fail to perform its intended function with possible damage both to structure and life, including complete damage.

3.2 THE AIM OF THE STRUCTURAL DESIGN

The following aims must be taken into consideration:

1. Ensure structural safety, which implies providing adequate stiffness and reinforcements to contain deflections and cracks.
2. Durability: The structure should last for a reasonable period.
3. Produce a structure that is capable to resist all applied loads without failure during its service life.
4. Obtain the economical dimensions of structural members. 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.
5. Stability to stop overturning, slipping, or buckling of the frame, or sections thereof, under load motion.
6. Investigate the strength and rigidity of structures.

3.3 STAGES OF STRUCTURAL DESIGN

Structural design stages can be divided into two main stages:

3.3.1 The First Stage:

It is the preliminary study of the project in terms of the nature and size of the project, in addition to understanding the project from all its various aspects, determining the building materials that will be approved for the project, then making the basic structural analyzes of this system, and the expected preliminary dimensions of it.

3.3.2 The Second Stage:

It is represented in the structural design of each part of the structure, in a detailed and accurate manner, according to the structural system that was chosen and the necessary structural details for it in terms of drawing horizontal projections, vertical sectors, and details of the reinforcement steel.

3.4 LOADS ACTING ON THE BUILDING

The loads to which the building is exposed are divided into different types, which are as follows:

3.4.1 Dead Load:

They are the loads resulting from the self-weight of the main elements that make up the structure, permanently and steadily, in terms of size and location, in addition to additional parts such as the various internal partitions and any mechanical works or additions that are carried out permanently and steadily in the building, and they can be calculated by determining the dimensions of the structural element, and the densities Its constituent materials, and Table (3.1) shows the specific densities of the materials used in the project.

Table3.1 : The Specific Densities Of The Materials

MATERIALS USED	SPECIFIC DENSITIES USED (KN/m^3)
Reinforced concrete	**25**
Tiles	**23**
Mortar	**22**
Plaster	**22**
Sand Fill	**17**
Hollow block	**10**

Partition = 2.3 KN/m^2

3.4.2 Live Load:

These are loads that change in quantity and location continuously, such as people, furniture, appliances, and equipment, and implementation loads such as lumber and equipment. The value of these loads depends on the nature of the facility's use.

These are loads whose quantity and location change continuously, such as people, furniture, appliances, and equipment, and implementation loads, such as wood and equipment. The value of these loads depends on the nature of the facility's use.

The live loads in the project were determined through the Jordanian code: 4 KN/m

Table3.2 : Live loads from the Jordanian code

الحمل المركز البديل	الحمل الموزع	الاستعمال (الاشغال)	نوع المبنى	
كن	كن/م2		خاص	عام
1.400	2.000	جميع الغرف بما في ذلك غرف النوم والمطابخ وغرف الغسيل وما شابه ذلك	المنازل والبيوت والشقق السكنية والأبنية ذات الطابق الواحد.	المباني السكنية والخاصة
1.800	2.000	غرف النوم	الفنادق والموتيلات والمستشفيات	
1.800	2.000	غرف وقاعات النوم	منازل الطلبة وما شابهها	
-	4.000	مقاعد ثابتة	القاعات العامة وقاعات التجمع والمساجد والكنائس وقاعات التدريس والمسارح ودور السينما وقاعات التجمع في المدارس والكليات والنوادي والمدرجات المسقوفة والقاعات الرياضية المغلقة	المباني العامة
3.600	5.000	مقاعد غير ثابتة		

3.4.3 Environmental loads :

1) Wind Load:

These are the loads that the wind exerts on one or some of the facades of the building, whether the effect is pressure or absorption. As for the factors on which the value of these loads depends, they are the height and shape of the building, the speed and intensity of the wind, and the location of the building in relation to the buildings surrounding it.

The value of wind loads is determined based on the maximum wind speed, which changes with height above the ground. The wind force is calculated based on its maximum speed, taking into account the topography of the area and the location of the building in relation to neighboring buildings.

2) Seismic Load:

These are the loads that earthquakes affect buildings. The value of these loads depends on several factors, the most important of which is the location of the construction area in terms of it being seismically active, as well as the proximity or distance of the seismic focus from the surface of the earth.

3) Snow loads:

It is the load resulting from snow on different surfaces. As for its value, it depends on the height of the geographical area in which the building is located above sea level. It also depends on the degree of inclination of the snow-covered surfaces from the horizontal. Snow loads can be calculated using the Jordanian code.

The following table shows the value of heat loads according to height above sea level according to the Jordanian code.

Table 3.3 : The value of Snow loads according to height above sea level

Snow loads (KN /M^2)	**The height of the structure above the surface of the earth (M)**
0	H < 250
(h-250) / 1000	h > 250 < 500
(h-400) / 400	h > 500 < 1500
(h – 812.5) / 250	h > 1500 < 2500

Table 3.4 : Surface shape coefficient for snow loads

Roof Pitch Angle α°	Shape Factor μ1
α ≥ 60°	μ1 = 0
30° < α < 60°	μ1 = 0.8 [(60 - α) / 30]
0° ≤ α ≤ 30°	μ1 = 0.8

Calculating snow loads in the city of Nimra:

Sd $= \mu i * s0$

h = 985 m (reduce level) …. 1500 > h > 500

$s0 = \frac{h-400}{400} = \frac{985-400}{400}$ = 1.4625 (KN/m^2)

$\mu i = 0.8$

…………… Sd $= \mu i * s0$

…………….. Sd $= 0.8 * 1.4625 = 1.17 \frac{KN}{m2}$

3.5 STRUCTURAL ELEMENTS OF THE BUILDING

Buildings usually consist of a group of structural elements that intersect with each other to bear the loads on the building, including:

3.5.1 Slabs:

- After studying the building architecturally and structurally, this type of panels was used in the design:
- **One-way ribbed slab**

  It's the most common system used in Palestine. It consists of a row of bricks followed by the rib, and the reinforcement is in one direction

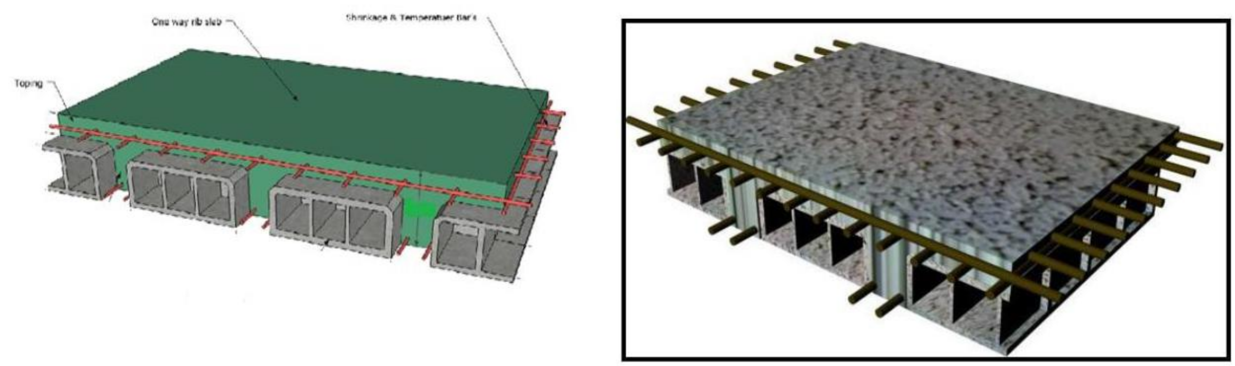


Figure 3.2: One-Way Ribbed Slab

- **Two -way ribbed slab**

also known as a waffle slab, is designed with ribs in two perpendicular directions on its underside to increase its strength and reduce weight. This type of slab is commonly used in large floor areas requiring substantial load-bearing capacity, such as auditoriums, parking garages, and commercial buildings.

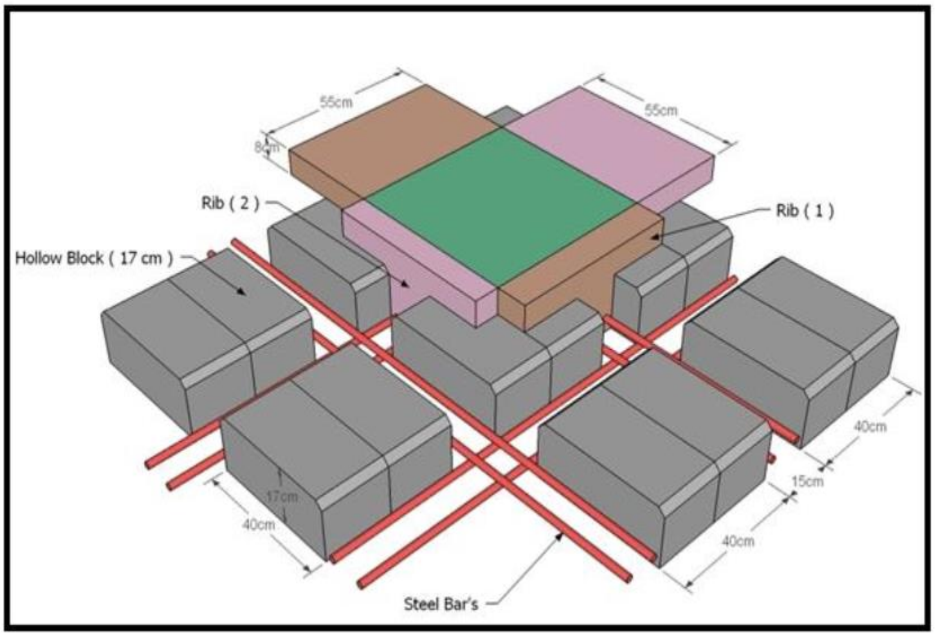


Figure.3.3: Two-Way Ribbed Slab

- **Solid Slab**

It is a reinforced concrete slab. It can be said that one of the disadvantages of this node is that it is expensive due to the increased amount of concrete and reinforcement, and the weight of the node is greater than the nerve node.

In each of the previous two types, the loads are distributed either in one direction or in two directions. The difference between the knot in one direction or in two directions is that in the case of the knot in one direction, the reinforcement is main towards the main load-bearing beams, in addition to secondary reinforcement towards the secondary beams.

In the second type, the reinforcement is main in both directions, and the load is transferred in both directions towards the main bridges surrounding them.

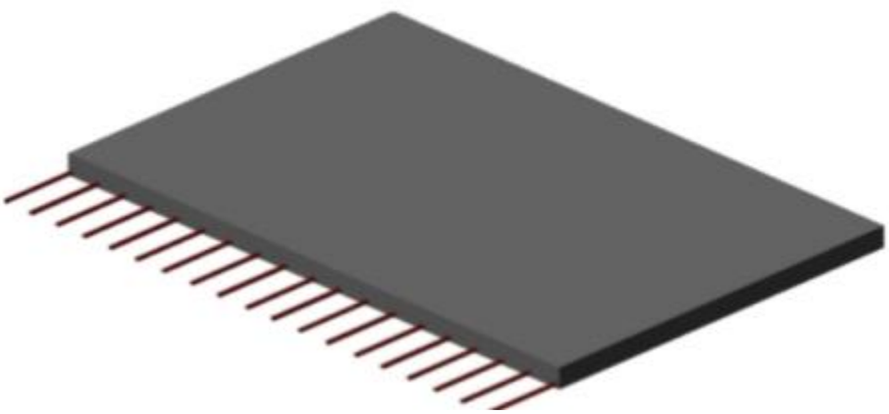


Figure 3.4 : One-Way Solid Slab

3.5.2 Beams:

They are essential structural elements in transferring loads from the nerves inside the node to the columns. They are of two types: enchanted bridges (hidden inside the nodes) and "Droped Beams", which protrude from the node from the bottom, and given the close distances between the columns in the building to be designed in this project. In addition to the applied loads, the bridges that will be used in the node will be enchanted bridges that transfer the nerve loads to it.

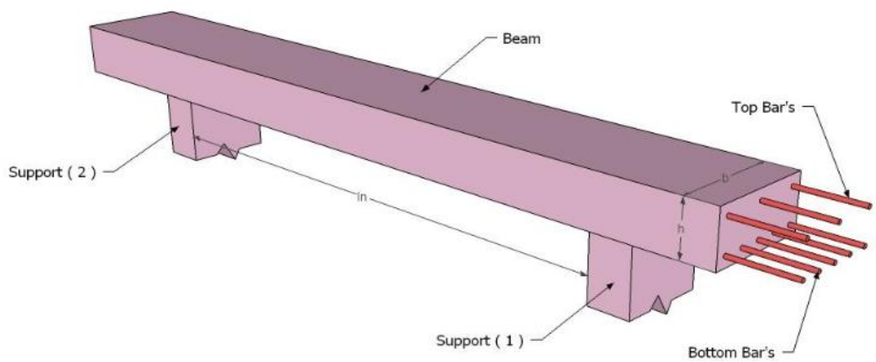


Figure 3.5: Longitudinal section of an enchanted bridge

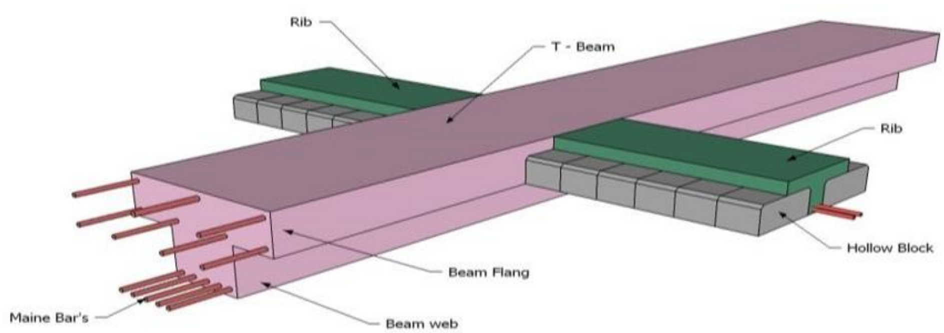


Figure 3.6: Cross section of a Droped Beams

3.5.3 Columns :

They are basic and main structural elements in the structure, as the loads are transferred from the slab to the bridges, and the bridges in turn transfer them to the columns, and then to the foundations of the building, so they are an essential intermediate element, and must be carefully designed to be able to transfer and distribute the loads falling on them. Columns are divided into two types. In terms of dealing with it in structural design:

1- Short columns.

2- Long columns.

As for the architectural shape or geometric section, the project contains three types of columns: square, rectangular, and circular.

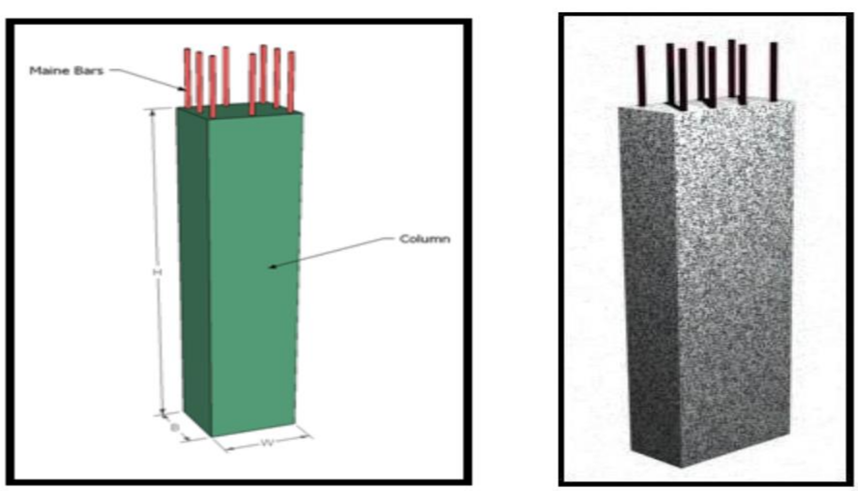


Figure 3. 7: Section in a column

3.5.4 Expasion Joint :

In building blocks with large horizontal dimensions or with special shapes and conditions, thermal expansion joints or landing joints are performed. Joints may be for both purposes. When structures are analyzed for resistance to earthquake effects, these joints are called seismic joints. These joints have some requirements and recommendations of their own, and thermal expansion joints must be used in the building block according to the approved code, provided that these joints reach the upper face of the foundations without penetrating them, and the maximum distances for the foundations and the dimensions of the building block are as follows:

• From 40 to 45 m in temperate regions, as is the case in Palestine.

• From 30 to 35 celsius in hot areas.

3.5.5 Foundations :

Foundations are the first thing that begins to be implemented during construction, but they are designed after designing all the basic elements in the building, as the foundations transfer loads from the columns and load-bearing walls to the soil in the form of strength

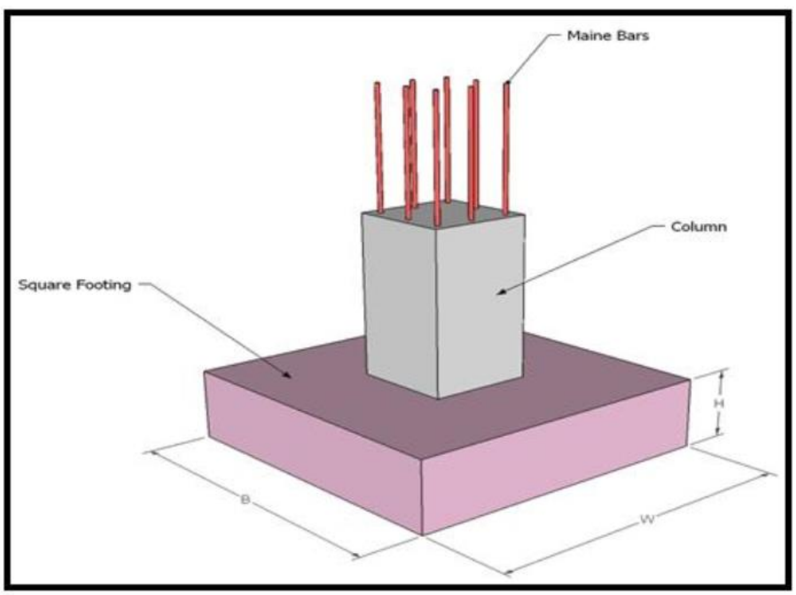


Figure 3.8: Vertical sector in the separated base

3.5.6 The Stairs :

It is an essential element in the building whose function is to ensure communication between the different levels. For this purpose, it consists of steps whose dimensions are proportional to the measurements of a walking person's step.

The staircase consists of the following elements:

1- Flight : it is a group of steps in one direction

2- Landing : it is the element of communication between the hearts and the shores

3- Parapet : it is an element surrounding the cores or edges of the stairs

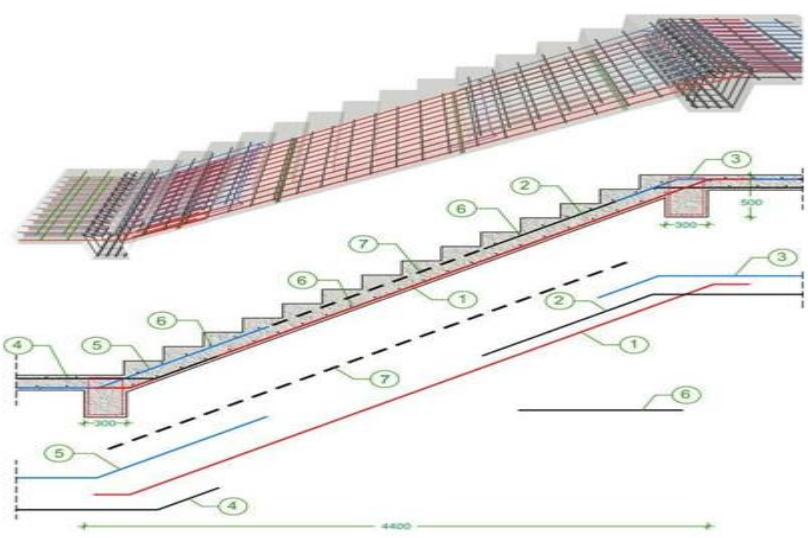


Figure 3.9: Stairs

3.5.7 Shear Wall :

Due to the presence of continuous walls that start from the foundations of the building until the highest level in the building, which is represented by the walls of staircases and the walls of electric elevators, the shear wall system is used to resist horizontal forces.

In this case, in order for these walls to be sufficient to prevent or reduce the generation of torques and their impact on the building walls that resist horizontal forces, it is preferable that the difference between the center of gravity of the shear walls does not exceed (1/6) the total length of the building in that direction.

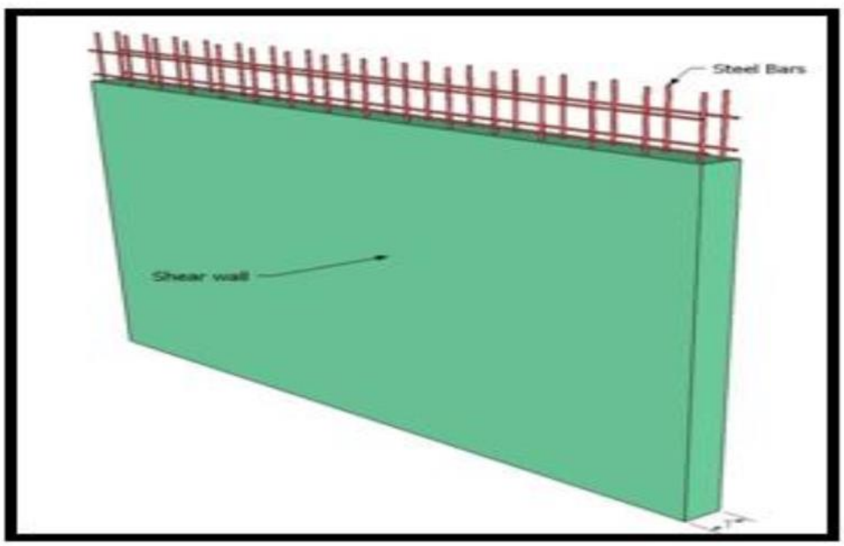


Figure 3.10: Shear wall

CHAPTER 4
"STRUCTURAL ANALYSIS AND DESIGN"

4.1 INTRODUCTION.

4.2 DESIGN METHOD AND REQUIREMENTS.

4.3 FACTORED LOAD.

4.4 DETERMINATION OF SLABS THICKNESS.

4.5 DESIGN OF TOPPING.

4.6 DETERMINATION OF SLABS LOADS.

4.7 DESIGN OF ONE-WAY RIBBED SLAB.

4.8 DESIGN OF BEAM.

4.9 DESIGN OF COLUMN C(24).

4.10 DESIGN OF BASEMENT WALL.

4.10 DESIGN OF FOOTING(F1).

4.11 DESIGN OF STAIR.

4.12 DESIGN OF STAIR.

4.13 SEISMIC DESIGN.

4.1 INTRODUCTION

Normal plain concrete can withstand compressive stress but does not do well with tensile and stresses such as those caused by wind, earthquakes.

Reinforced concrete contains steel embedded in the concrete so the two materials complement each other to resist forces such as tensile, shear and compressive stress in the concrete structure.

This project contains two type of slab, which are "one-way ribbed slab" and "solid slab" , which will be analyzed and designed using the finite element design method with the help of a computer program called "Beam D-Software" to find the internal forces, deflections and moments of the ribbed slab, and then calculate Handle to find the steel required for all members.

4.2 DESIGN METHOD AND REQUIREMENTS

The design strength provided by a member is calculated according to the requirements and assumptions of ACI-code (318-19).

4.2.1 Ultimate Strength Design Method:

In this method, the reinforced concrete structure is designed beyond the elastic region. the working dead load and live load are multiplied by a factor of safety. the section designed to fail at factored load. failure at factored load means the section exceeds the elastic region to ultimate strength then failure.

The computation of this strength takes into account the nonlinear stress-strain behavior of concrete. The strength design method is expressed by the following,

Strength provided ≥ strength required to carry factored loads.

4.2.2 Materials:

Reinforced Concrete: B300, $f_{\acute{c}}$ = 24 N/mm^2 (Mpa)

Reinforcement Rebars: f_y = 420 N/mm^2 (Mpa)

4.3 FACTORED LOAD

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:

$$q_u = 1.2DL + 1.6LL \quad \text{......... } ACI - 318 - 19$$

Where;

q_u: Ultimate Load (KN)

D_L: Dead Load (KN)

L_L: Live Load (KN)

4.4 DETERMINATION OF SLAB THICKNESS

Minimum Thickness of Non prestressed Beam or One-Way Slabs Unless Deflections are Calculated. **(**ACI-Code-318-19**)**

Table 4.1 : Check Of Minimum Thickness Of Structural Member.

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

The final thickness of the slab will be determined based on the deformation that will be calculated through the design programs because the slab is originally one-way ribbed slab.

Slab Thickness:

- **All floors**

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

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

  = 661/18.5 = **35.7 cm.**

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

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

  = 640/21 = **30.5 cm.**

Selected a preliminary first floor slab thickness of the ribbed slabs thickness = 35 cm.

4.5 DESIGN OF TOPPING

These calculations are for the first basement floor ,The live load in this case equals **4 KN/m** according to the Jordanian code

Consider the Topping as strip of (1m) width

Consider the Topping as strip of (1m) width.

Table 4.2:
Dead Load Calculation:

Dead Load from:	δ	γ	b	δ*γ*1=KN/m
Tiles	0.03	23	1	0.69
Mortar	0.03	22	1	0.66
Coarse sand	0.07	17	1	1.19
Topping	0.08	25	1	2
Interior Partitions	2.3		1	2.3
			$\sum$	6.84

Live Load For 1m strip = 4 KN/m^2 × 1 = **4 KN/m**

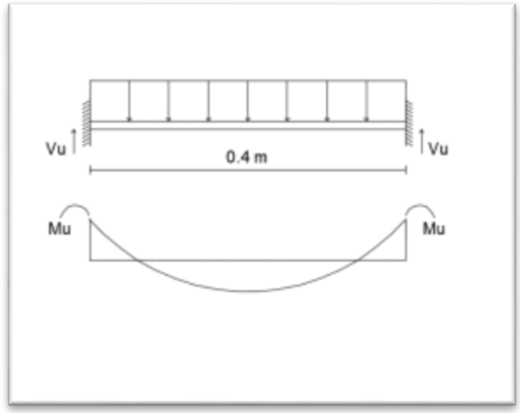


Figure 4.1: Topping Load

- ✓ Factored load:

  W_u= 1.2 ×6.84 + 1.6×4 = 14.608 KN/m

- ✓ Check the strength condition for plain concrete:

  $\emptyset M_n \geq M_u$, where $\emptyset$= 0.55

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

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

$\emptyset M_n$ =0.55×0.42×1×$\sqrt{24}$ ×1066666.67 ×10^{-6} =1.2 KN.m

$M_u = \frac{W_u L^2}{12} = 0.195$ KN.m (negative moment)

$M_u = \frac{W_u L^2}{24} = 0.097$ KN.m (positive moment)

$\emptyset M_n >> M_u = 0.195$ KN.m

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

$\rho_{shrinkage}$= 0.0018

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

Step (s) is the smallest of:

1. 3h = 3×80 =240 mm …… control
2. 450 mm.
3. S =$380\left(\frac{280}{f_s}\right) - 2.5C = 380\left(\frac{280}{\frac{2}{3}(420)}\right) - 2.5 \times 20 = 330$ mm

Take ∅ 8 @ 200 mm in both direction, S = 200 mm <S_{max} = 240 mm … OK

4.6 DETERMINATION OF SLABS LOADS

One-Way Ribbed Slab.

- **First Basement Floors**

Table 4.3 : Dead Load with One-Way Ribbed Slab.

Dead Load Calculation:

Dead Load from:	δ	γ	b	$\delta*\gamma*1$=KN/m/rib
Tiles	0.03	23	0.52	0.3588
Mortar	0.03	22	0.52	0.3432
Coarse sand	0.07	17	0.52	0.6188
Topping	0.08	25	0.52	1.04
RC Rib	0.27	25	0.12	0.81
Hollow Block	0.27	10	0.4	1.08
Plaster	0.02	22	0.52	0.2288
Interior Partitions	2.3		0.52	1.196
			∑	5.6756

Nominal Total Dead load = 5.6756KN/m/rib.

Nominal Total Live load = 4* 0.52 = 2.08 KN/m/rib

4.7 DESIGN of ONE-WAY RIBBED SLAB(24)

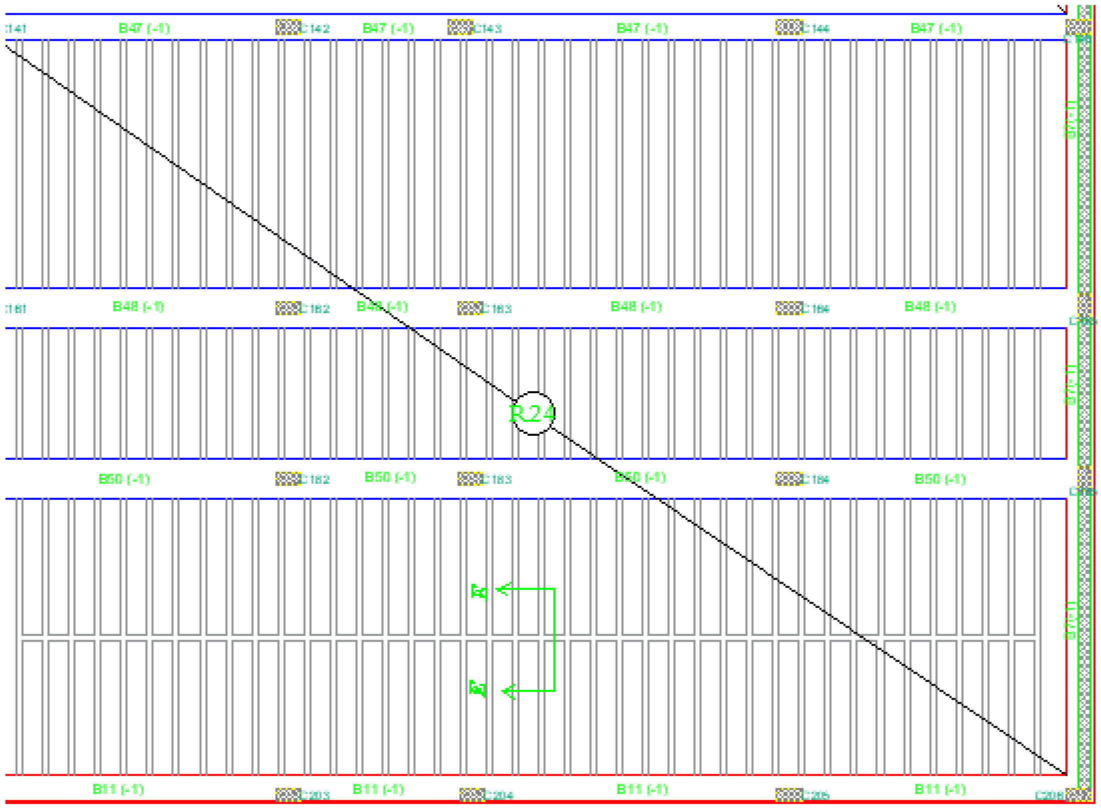


Figure 4.2 : Rib (24)

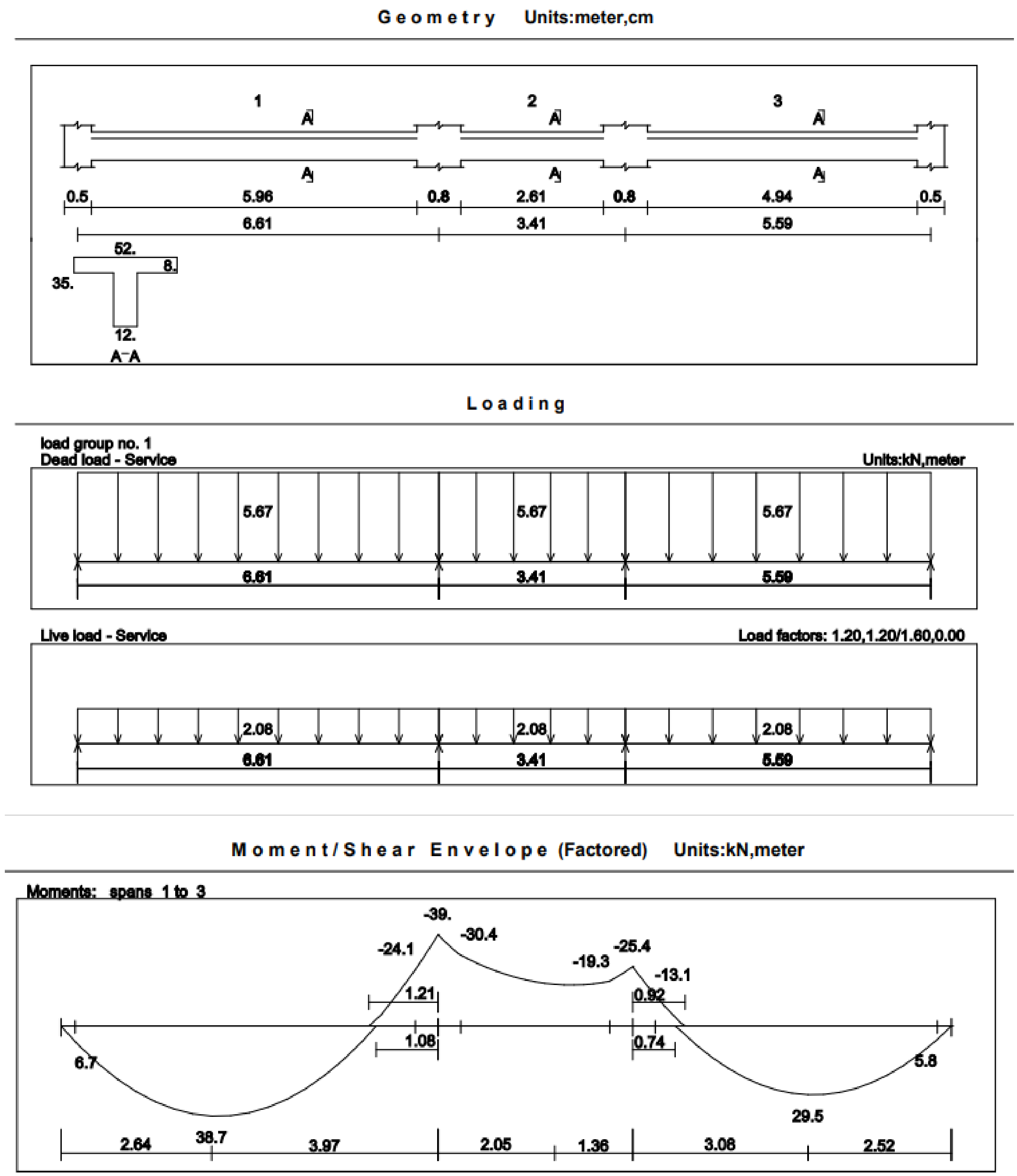


Figure 4.3 Geometry load & Moment Envelop diagram for Rib 24

- Material:

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel Fy = 420 N/mm^2

- Section:

b =12cm b_f= 52 cm

h =35cm T_f = 8 cm

- Factored load:

W_u= (1.2 ×5.2596) + (1.6×2.08) = 9.6395 KN/m

$M_u = \frac{WL^2}{12} = \frac{9.6395 \times 0.4^2}{12}$ = 0.1285 KN.m

$$\emptyset Mn = \emptyset \times 0.42 \times \sqrt{f\acute{c}} \times b \times \frac{h^2}{6} = 1.207\ KN.m$$

$\emptyset Mn > M_u$

use shrinkage and temperature reinforcement

4.7.1 Design For Flexure:

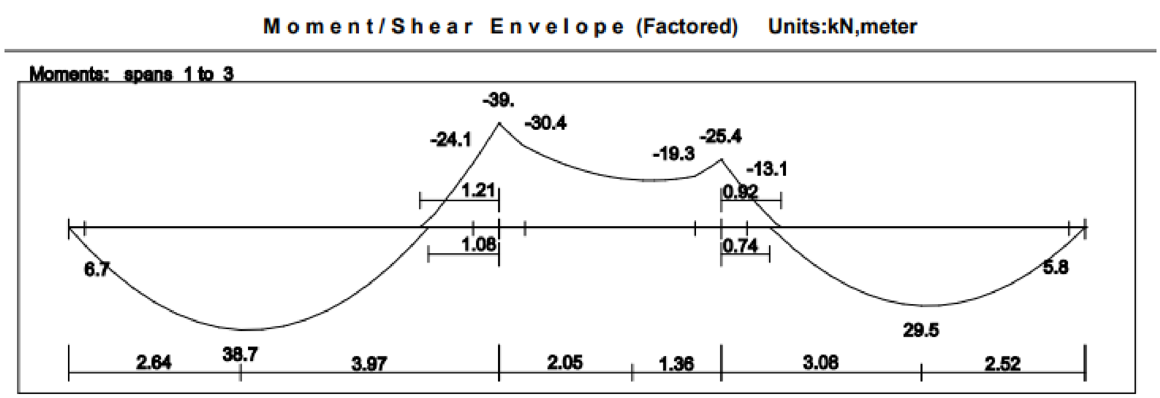


Figure 4.4 : Moment Envelop

✓ Design for positive moment (M_u=38.7 KN.m)

Assume bar diameter Ø16 for main reinforcement.

Assume bar diameter Ø10 for stirrups.

$D = 350 - 20 - 10 - \frac{10}{2} = 315$ mm

bE= distance center to center between ribs = 520mm

Check if $a > h_f$:

$\overline{Mn_f} = 0.85 f_{\acute{c}}\, b\, h_f (d - \frac{h_f}{2}) = 0.85 \times 24 \times 520 \times 80 \times (315 - \frac{80}{2}) \times 10^{-6} = 233.4$ KN.m

$\overline{Mn_f} \gg M_u$ .... $a < h_f$ ➡ The section is as Rectangular section

$k_n = \frac{M_u}{\emptyset b d^2} = \frac{36.6 \times 10^6}{0.9 \times 520 \times 315^2} = 0.7882$ Mpa

$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.6$

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times K_n}{f_y}}) = \frac{1}{20.6}(1 - \sqrt{1 - \frac{2 \times 20.6 \times 0.7882}{420}}) = 0.0019$

$A_s = \rho \times b \times d = 0.0019 \times 520 \times 315 = 313.575$ mm^2…… Control

$A_{s_{min}} = 0.25 \times \frac{\sqrt{f_{\acute{c}}}}{f_y} \times b_w \times d \geq \frac{1.4}{f_y} \times b_w \times d$

$A_{s_{min}} = 0.25 \times \frac{\sqrt{24}}{420} \times 120 \times 315 \geq \frac{1.4}{420} \times 120 \times 315$

$A_{s_{min}} = 110.23$ mm$^2 \leq 126$ mm^2

$A_s = 313.575\, mm^2 \geq A_{s_{min}} = 126$

Use 2Ø16

$A_{s\,provid} = 402.124 > A_{s\,req} = 313.575$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{402 \times 420}{0.85 \times 24 \times 520}$ 15.9 mm

$c = \frac{a}{0.85} = \frac{15.9}{0.85}$ =18.7 mm

$\varepsilon_s = 0.003 \left(\frac{d-c}{c}\right) = 0.003\ (\frac{315-18.7}{18.7}) = 0.048 > 0.005$ OK.

- ✓ Design for positive moment (M_u=24.1 KN.m)

D = $350 - 20 - 10 - \frac{10}{2} = 315$ mm

$k_n = \frac{M_u}{\emptyset b d^2} = \frac{27.9 \times 10^6}{0.9 \times 520 \times 315^2} = 0.6008$ Mpa

m = $\frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.6$

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times K_n}{f_y}}) = \frac{1}{20.6}(1 - \sqrt{1 - \frac{2 \times 20.6 \times 0.6008}{420}}) = 0.0015$

$A_s = \rho \times b \times d = 0.0015 \times 520 \times 315$ =237.9 mm^2…… Control

$A_{s_{min}} = 0.25 \times \frac{\sqrt{f_{\acute{c}}}}{f_y} \times b_w \times d \ \geq \ \frac{1.4}{f_y} \times b_w \times d$

$A_{s_{min}} = 0.25 \times \frac{\sqrt{24}}{420} \times 120 \times 315 \ \geq \ \frac{1.4}{420} \times 120 \times 315$

$A_{s_{min}}$ = 110.23 mm^2 ≤ 126 mm^2

$A_s = 237.9\ mm^2 \geq A_{s_{min}} = 126$

<u>Use 2Ø14</u>

$A_{s\ provid} = 307.87 > A_{s\ req} = 237.9$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{308 \times 420}{0.85 \times 24 \times 520} = 12.2$ mm

$c = \frac{a}{0.85} = \frac{12.2}{0.85} =$ 14.3 mm

$\varepsilon_s = 0.003 \left(\frac{d-c}{c}\right) = 0.003\ (\frac{315-14.3}{14.3}) = 0.06 > 0.005$ OK.

- ✓ Design for Negative moment (M_u=29.5 KN.m)

$D = 350 - 20 - 10 - \frac{10}{2} = 315$ mm

$k_n = \frac{M_u}{\emptyset b d^2} = \frac{28.8\times10^6}{0.9\times520\times315^2} = 0.6202$Mpa

$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2\times m\times K_n}{f_y}}) = \frac{1}{20.58}(1 - \sqrt{1 - \frac{2\times20.6\times0.6202}{420}}) = 0.0015$

$A_s = \rho \times b \times d = 0.0015 \times 520 \times 315 = 245.7$ mm^2…… Control

$A_{s_{min}} = 0.25 \times \frac{\sqrt{f_{\acute{c}}}}{f_y} \times b_w \times d \ \geq \ \frac{1.4}{f_y} \times b_w \times d$

$A_{s_{min}} = 0.25 \times \frac{\sqrt{24}}{420} \times 120 \times 315 \ \geq \ \frac{1.4}{420} \times 120 \times 315$

$A_{s_{min}} = 110.23$ mm$^2 \leq 126$ mm^2

$A_s = 245.79\, mm^2 \geq A_{s_{min}} = 126$

Use 2Ø14

$A_{s\,provid} = 307.87 > A_{s\,req} = 245.79$

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

$a = \frac{A_s\times f_y}{0.85\times f_{\acute{c}}\times b} = \frac{308\times420}{0.85\times24\times520} = 12.2$ mm

$c = \frac{a}{0.85} = \frac{12.2}{0.85} = 14.4$ mm

$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\,(\frac{315-14.4}{14.4}) = 0.06 > 0.005$ **OK.**

4.7.2 Design For Shear:

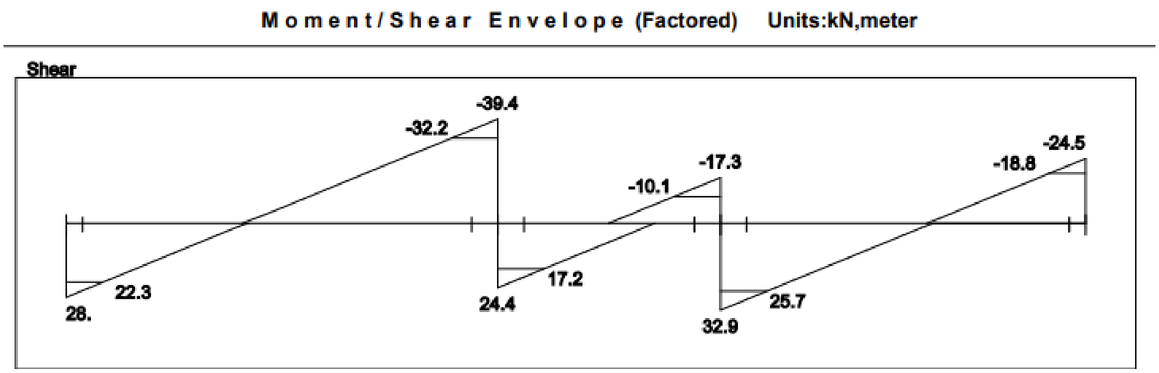


Figure 4.5: Shear Envelope

- ✓ Design for Shear(Vu=32.2 KN)

D = 350 – 20 – 8 – 6 = 316 mm

$\emptyset Vc = 1.1 \times \emptyset \frac{1}{6} \times \sqrt{f\acute{c}} \times \text{bw} \times \text{d} = 1.1 \times \frac{0.75}{6} \times \sqrt{24} \times 0.12 \times 0.316 \times 10^3 =$ $25.54\ KN$

$\frac{1}{2}\emptyset V_c = \frac{1}{2} \times 25.53 = 12.77$ KN

Check for Cases:

Case 1: Vu $<\frac{1}{2}\emptyset V_c$

32.2>12.77 …… case 1 is NOT satisfied

Case2: $\frac{1}{2}\emptyset V_c < \text{Vu} < \emptyset Vc$

12.77<32.2<25.54…… case 2 is NOT satisfied

Case 3: $\emptyset Vc < \text{Vu} <(\emptyset Vc + \emptyset V_{s\,min})$

$$\emptyset V_{s\,min} = \frac{\emptyset}{3} \times \text{bw} \times \text{d} = \frac{0.75}{3} \times 0.12 \times 0.316 \times 10^3 = 9.45 \dots\dots\dots control$$

$$\emptyset V_{s\,min} = \frac{\emptyset}{16} \times \sqrt{f\acute{c}} \times \text{bw} \times \text{d} = \frac{0.75}{16} \times \sqrt{24} \times 0.12 \times 0.316 \times 10^3 = 8.7$$

$\emptyset Vc + \emptyset V_{s\ min} = 25.54 + 9.45 = 34.9$

25.54< $32.2 < 34.9$

Shear design for Item 3

$\frac{Av}{s} min = \frac{1}{3} \times \frac{\sqrt{f\acute{c}} \times \mathrm{bw}}{\mathrm{fyt}} = \frac{1}{16} \times \frac{0.12}{420} = 9.5 \times 10^{-5} KN$ ……control

$= \frac{1}{16} \times \frac{\mathrm{bw}}{\mathrm{fyt}} = \frac{1}{16} \times \frac{\sqrt{24} \times 0.12}{420} = 8.7 \times 10^{-5} KN$

Use 2Ø10 Try Ø 10 With 2 Legs with As =157.1 mm2

$\frac{2 \times 50 \times 10^{-6}}{s} = 9.5 \times 10^{-5}$

$s = 1.05$ m

S max < (d / 2)   OR S max < 600 mm

S= $\frac{\mathrm{d}}{2} = \frac{316}{2} = 158mm$

$s\ max < 158mm \quad OR \quad s\ \mathrm{max} < 600mm$

$\mathrm{S\ max} < 158 \ldots \ldots \ldots \ldots . control$

$\mathrm{s\ max} = 158 > \mathrm{s} = 105\ \mathrm{take\ s} = 110\ mm\ use\ \emptyset 10\ with\ 2\ legs\ /110mm$

4.8 Design Of Beam:

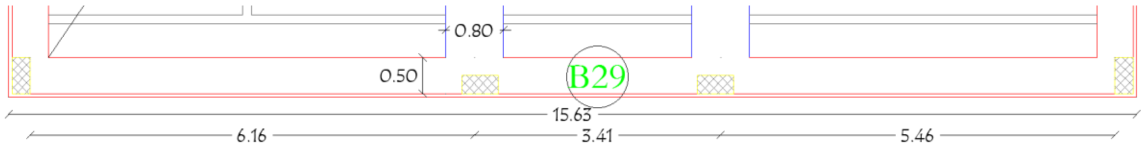


Figure 4.6 : Beam (24).

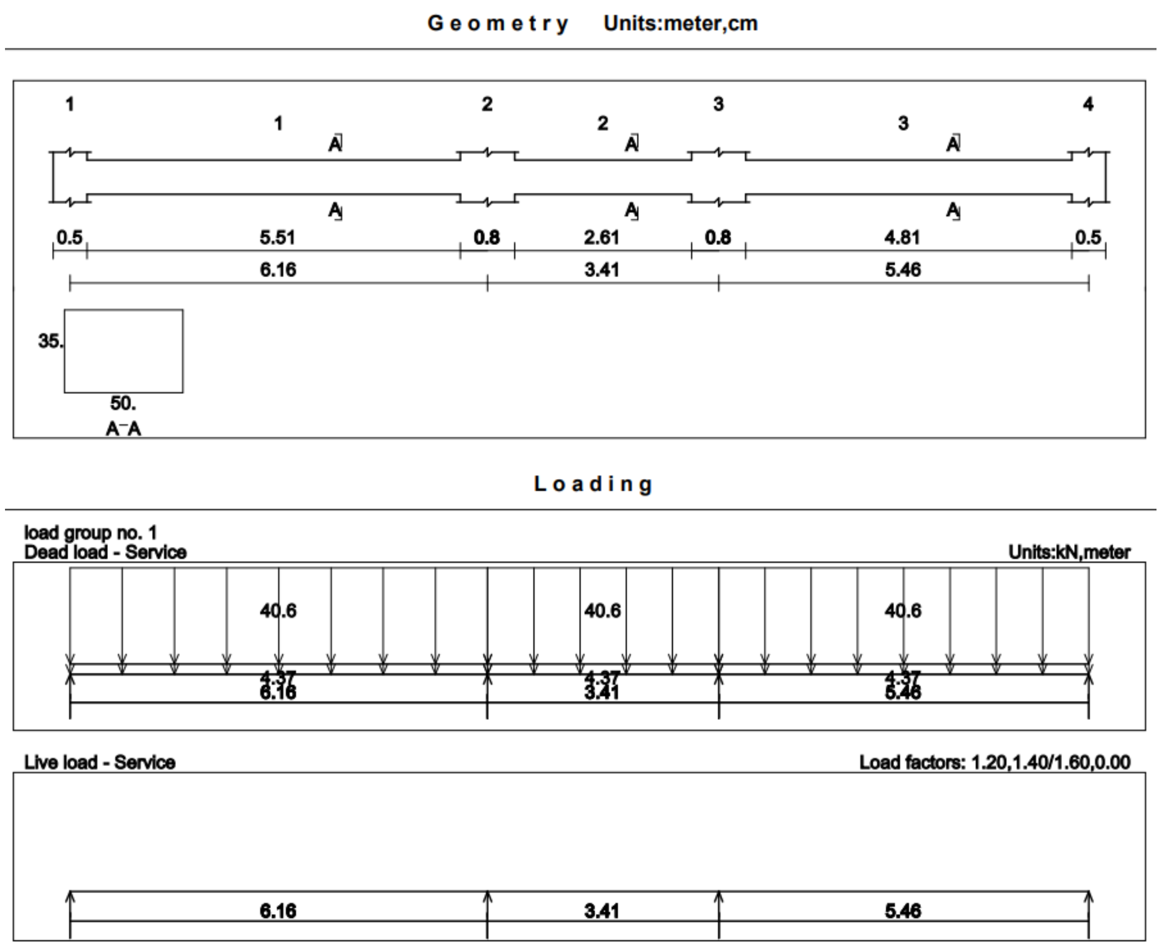


Figure 4.7 : Beam loading & Geometry in Building .

- ✓ Material:

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel Fy = 420 N/mm^2

✓ Section:

b =50cm

h =35cm

✓ Factored load:

Total Dead load = Wall weight =width× height× density =0.5 ×3.25 ×25= 40.625KN/m/rib

Total Live load = 0 KN/m/rib

Design For Flexure:

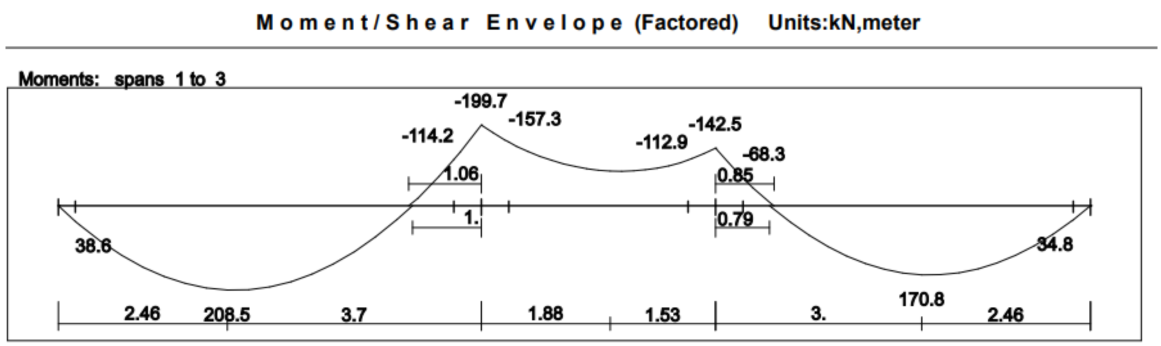


Figure 4.8 : Moment Envelop

✓ Design for possitive moment (M_u=208.5 KN.m)

$$D = 350 - 20 - 10 - \frac{10}{2} = 315 \text{ mm}$$

$$Cmax = \frac{3}{7}d = 135mm$$

$$amax = 0.85 * 135 = 114.75$$

$$\overline{\emptyset Mn_f} = \emptyset * 0.85 * f_{\acute{c}} * b * a * (d - \frac{a}{2}) = 0.82 \times 0.85 \times 24 \times 0.8 \times 0.1148 \times (0.315 - \frac{0.1148}{2}) \times 10^3 = 395.8 \text{ KN.m} > Mu = 208.5$$

use singly reinforced concrete section.

$$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.6$$

$$K_n = \frac{M_u}{\emptyset b d^2} = \frac{208.5 \times 10^{-3}}{0.9 \times 0.8 \times 0.315^2} = 2.9 \text{ Mpa}$$

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times K_n}{f_y}}) = \frac{1}{20.6}(1 - \sqrt{1 - \frac{2 \times 2.9 \times 20.6}{420}}) = 0.0075$

$A_s = \rho \times b \times d = 0.0075 \times 800 \times 315 = 1890 mm^2$

$A_{s_{min}} = \frac{\sqrt{f\acute{c}}}{4 \times f_y} \times b \times d \geq \frac{1.4}{f_y} \times b \times d$

$A_{s_{min}} = \frac{\sqrt{24}}{4 \times 420} \times 500 \times 315 \geq \frac{1.4}{420} \times 500 \times 315$

$A_{s_{min}} = 459.28 \text{ mm}^2 \leq 525 \text{ mm}^2$

$A_s = 1890\, mm^2 > A_{s_{min}} = 525$

Use 8Ø18

$A_{s\, provid} = 2035.8 > A_{s\, req} = 1890$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{2035.8 \times 420}{0.85 \times 24 \times 500} = 83.8 \text{ mm}$

$c = \frac{a}{0.85} = \frac{83.8}{0.85} = 98.6 \text{ mm}$

$\varepsilon_s = 0.003\left(\frac{d-c}{d}\right) = 0.003\,(\frac{315-98.6}{98.6}) = 0.0066 > 0.005$ OK.

✓ Design for possitive moment (M_u=170.8 KN.m)

$D = 350 - 20 - 10 - \frac{10}{2} = 315 \text{ mm}$

$Cmax = \frac{3}{7}d = 135mm$

$amax = 0.85 * 135 = 114.75$

$\overline{\emptyset M n_f} = \emptyset * 0.85 * f_{\acute{c}} * \ b * a * (d - \frac{a}{2}) = 0.82 \times 0.85 \times 24 \times 0.8 \times 0.1148 \times (0.315 - \frac{0.1148}{2}) \times 10^3 = 395.8 \text{ KN.m} > Mu = 208.5$

use singly reinforced concrete section.

$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.6$

$K_n = \frac{M_u}{\emptyset b d^2} = \frac{170.8 \times 10^{-3}}{0.9 \times 0.8 \times 0.315^2} = 2.4 \text{ Mpa}$

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times K_n}{f_y}}) = \frac{1}{20.6}(1 - \sqrt{1 - \frac{2 \times 2.4 \times 20.6}{420}}) = 0.0061$

$A_s = \rho \times b \times d$ = 0.0061× 800 × 315 = 1537.2mm^2

$A_{s_{min}} = \frac{\sqrt{f_{\acute{c}}}}{4\times f_y} \times b \times d \geq \frac{1.4}{f_y} \times b \times d$

$A_{s_{min}} = \frac{\sqrt{24}}{4\times 420} \times 500 \times 315 \geq \frac{1.4}{420} \times 500 \times 315$

$A_{s_{min}}$ = 459.28 mm^2 ≤ 525 mm^2

$A_s = 1537.2\ mm^2 > A_{s_{min}} = 525$

Use 8∅16

$A_{s\ provid}$ **= 1608.5 >** $A_{s\ req}$ **= 1537.2**

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

$a = \frac{A_s \times f_y}{0.85\times f_{\acute{c}} \times b} = \frac{1608.5\times 420}{0.85\times 24\times 500}$ =66.23 mm

$c = \frac{a}{0.85} = \frac{66.23}{0.85}$ =77.9 mm

$\varepsilon_s = 0.003\left(\frac{d-c}{d}\right) = 0.003\ (\frac{315-77.9}{77.9}) = 0.0091 > 0.005$ **OK.**

✓ Design for Negative moment (M_u=157.3 KN.m)

$D = 350 - 20 - 10 - \frac{10}{2}$ = 315 mm

$Cmax = \frac{3}{7} d = 135mm$

$amax = 0.85 * 135 = 114.75$

$\overline{\emptyset Mn_f} = \emptyset * 0.85 * f_{\acute{c}} * b * a * (d - \frac{a}{2}) = 0.82 \times 0.85 \times 24 \times 0.8 \times 0.1148 \times (0.315 - \frac{0.1148}{2}) \times 10^3$ = 395.8 KN.m $> Mu = 157.3$

use singly reinforced concrete section.

$K_n = \frac{M_u}{\emptyset b d^2} = \frac{157.3\times 10^{-3}}{0.9\times 0.5\times 0.315^2}$ = 3.5 Mpa

m = $\frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85\times 24} = 20.6$

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2\times m\times K_n}{f_y}}) = \frac{1}{20.6}(1 - \sqrt{1 - \frac{2\times 3.5\times 20.6}{420}})$ = 0.0092

$A_s = \rho \times b \times d$ = 0.0092× 500 × 315 = 1449mm^2

$A_{s_{min}} = \frac{\sqrt{f_{\acute{c}}}}{4 \times f_y} \times b \times d \ \geq \ \frac{1.4}{f_y} \times b \times d$

$A_{s_{min}} = \frac{\sqrt{24}}{4 \times 420} \times 500 \times 315 \ \geq \ \frac{1.4}{420} \times 500 \times 315$

$A_{s_{min}}$ = 459.28 mm^2 ≤ 525 mm^2

$A_s = 1449\ mm^2 > A_{s_{min}} = 525$

Use 8Ø16

$A_{s\ provid} = 1608.5 > A_{s\ req} = 1449$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{1449 \times 420}{0.85 \times 24 \times 500}$ =59.66 mm

$c = \frac{a}{0.85} = \frac{59.66}{0.85}$ =70.2 mm

$\varepsilon_s = 0.003 \left(\frac{d-c}{d}\right) = 0.003 \left(\frac{315-70.2}{70.2}\right) = 0.010 > 0.005$ **OK.**

Design For Shear:

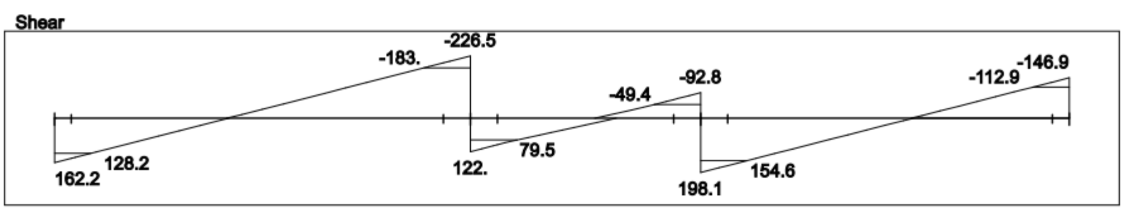


Figure 4.9: Shear Envelope

✓ ($V_{u,d} = 183\ KN$)

D = $350 - 40 - 10 - \frac{20}{2}$ = 290 mm

$$\emptyset Vc = \emptyset \frac{1}{6} \times \sqrt{f_{\acute{c}}} \times \text{bw} \times \text{d} = \frac{0.75}{6} \times \sqrt{24} \times 0.5 \times 0.29 \times 10^3 = 88.8\ KN$$

$\frac{1}{2} \emptyset V_c = \frac{1}{2} \times 88.8 = 44.4$ KN

Check for Cases:

Case 1: Vu $<\frac{1}{2}\emptyset V_c$

183>44.4 …… case 1 is NOT satisfied

Case2: $\frac{1}{2}\emptyset V_c <$ Vu $< \emptyset Vc$

44.4<183<88.8…… case 2 is NOT satisfied

Case 3: $\emptyset Vc <$ Vu $<(\emptyset Vc + \emptyset V_{s\ min})$

$$\emptyset V_{s\ min} = \frac{\emptyset}{3} \times \text{bw} \times \text{d} = \frac{0.75}{3} \times 0.5 \times 0.29 \times 10^3 = 36.25 \ldots\ldots\ldots.control$$

$$\emptyset V_{s\ min} = \frac{\emptyset}{16} \times \sqrt{f_{\acute{c}}} \times \text{bw} \times \text{d} = \frac{0.75}{16} \times \sqrt{24} \times 0.5 \times 0.29 \times 10^3 = 33.3$$

$\emptyset Vc + \emptyset V_{s\ min} = 88.8 + 36.25 = 125.05$

88.8$< 183 < 125.05$

Cace (3)is NOT satisfied

Cace 4: $(\emptyset Vc + \emptyset V_{s\ min})<$ Vu<(Vc+$\emptyset Vs'$)

$\emptyset Vs' = \frac{\emptyset}{3} \times \sqrt{f_{\acute{c}}} \times \text{bw} \times \text{d} = \frac{0.75}{3} \times \sqrt{24} \times 0.5 \times 0.29 \times 10^3 = 177.6$

$\emptyset Vc + \emptyset V_{s'}$ =88.8+177.6=206.4

125.0 $<$ 183 $<$206.4

Case 4 is statisfied

$Vs = \frac{Vu}{\emptyset} - vc = \frac{183}{0.75} - \frac{88.8}{0.75} = 125.6$

Use 2Ø10 Try Ø 10 With 2 Legs with As =157.1 mm2

S=($\frac{\text{Av} \times \text{fy} \times \text{d})}{Vs}$) $= 157.1 \times 420 \times \frac{290}{125.6} \times 10^{-3} = 152.7mm$

S max < (d / 2) OR S max < 600 mm

S= $\frac{\text{d}}{2} = \frac{290}{2} = 145mm$

$s\ max < 158mm$ OR s max $< 600mm$

S max $< 145 \ldots\ldots\ldots\ldots.control$

$s\ max = 145 < s = 152.7$

$\text{take } s = 150\ mm\ use\ \emptyset 10\ with\ 2\ legs\ /150mm$

4.9 Design of Column C59

✓ Material :-

⇒ concrete B350 $Fc' = 28\ N/mm^2$

⇒ Reinforcement Steel $Fy = 420\ N/mm^2$

✓ Load Calculation:-

Service Load:-

Dead Load =4873.6438 KN
Live Load =2124.9KN

Factored Load:-

$P_U = 1.2 \times 4873.6438 + 1.6 \times 2124.9 = 9248.21256KN$

✓ Check Slenderness Parameter:-

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \leq 40$$

Lu: Actual unsupported (Unbraced) length.
K: effective length factor. According to ACI-318-19 The effective length factor k, shall be permitted to be taken as 1.0.

R: radius of gyration = $\sqrt{\frac{I}{A}} \approx 0.3\ h$ ………………. For rectangular section
Lu =3.15 m
M1/M2 =1
K=1 for braced frame.

about X-axis (h= 0.55 m)

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \quad \leq 40$$

rx = 0.3h = 0.3 * 0.55= 0.165

$$\frac{1 \times 3.15}{0.165} = 19.09 < 22$$

Column Is Short About X-axis

about Y-axis (b= 0.8m)

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \quad \leq 40$$

ry = 0.3b = 0.3 * 0.8 = 0.24

$$\frac{1 \times 3.15}{0.24} = 13.125 < 22$$

Column Is Short About Y-axis

✓ Dimensions of Column:-

Po = $\frac{Pu}{0.65} = \frac{9248.21256}{0.65} = 14228.02$

Ag = $\frac{\text{Po}}{0.8*(0.85\text{fc}+0.01*(\text{fy}-0.85\text{fc}))}$

Ag = $\frac{14228.02 * 10\text{^}3}{0.8*420}$

= 42345.3mm^2

Select 550 * 800

Ag = 550 * 800 = 440000 >42345.3 ….. OK

Ast = $\frac{\text{Po}-0.85\ fc\ Ag}{fy-0.85\text{fc}}$

Ast = $\frac{(14228.02 * 10\text{^}3) - 0.85*28*440000}{fy-0.85*28}$

= 26431.1

Use 16 ø 20

Ast 16 ø 20 = 5026.548

$f = \frac{\text{Ast}}{Ag} = \frac{5026.548}{440000} = 0.011 > 0.1 \ldots \ldots OK$

✓ <u>Check</u> For Spacing Between Bars: -

X-axis ..

$S = \frac{550-(40*2)-(2*10)-(4*20)}{3}$ **= 123.3 mm <150 mm use S hook ..**

Y-axis

$S = \frac{800-(40*2)-(2*10)-(5*20)}{4}$ **= 150 mm use stirrups ..**

✓ Spacing Between Stirrups:-

Select smallest ..

S = 48 ds = 48 * 10 = 480 mm

S = 16 db = 16 * 20 = 320 mm…. Cont

S = $\frac{800}{2}$ = 400 mm

Select S = 200 mm

Use Tow Stirrups and One S hook @ 200 mm

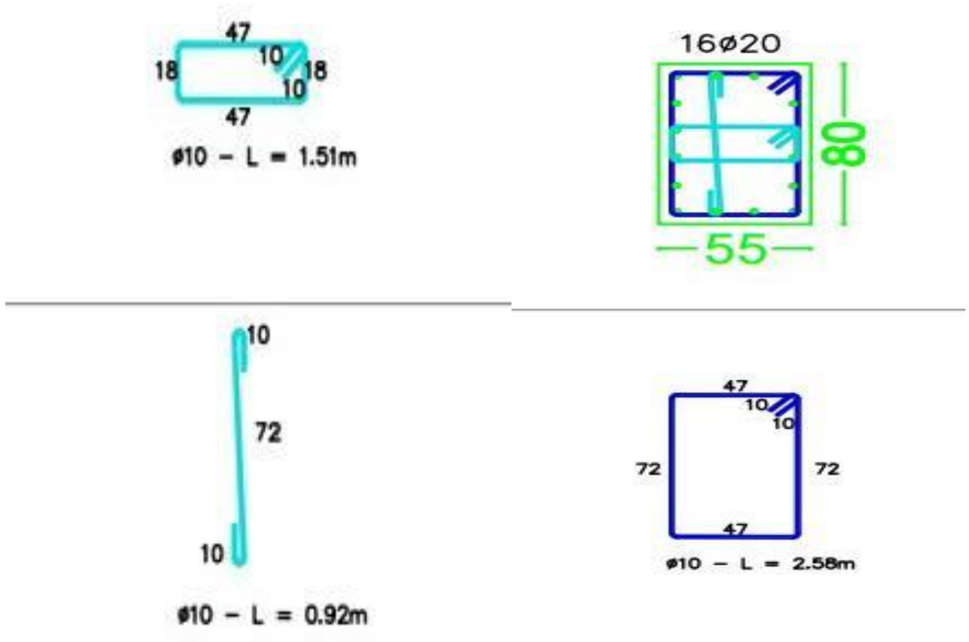


Figure 4.10 : Column C59 Detailing

4.10 Design of Basement wall :

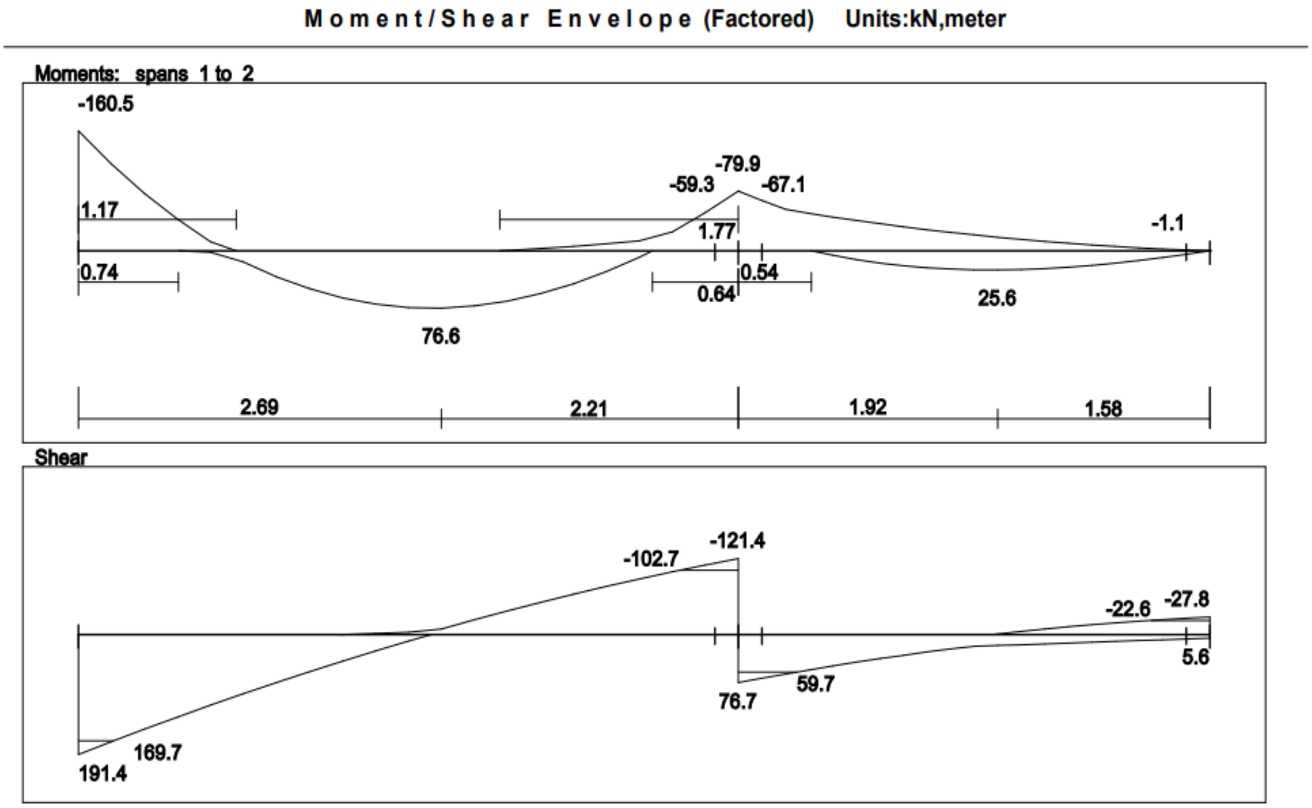


Figure 4-11: Moment & Shear Envelope deagram for Basement Wall

- ✓ Maximum moment $Mu^{(-)}$ = 160.5 kN.m

$$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 28} = 17.6$$

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

$$=400 - 70 - \frac{16}{2} = 322 \text{ mm}$$

$$R_n = \frac{M_n}{0.9 * b * d^2} = \frac{160.5 \ * 10^6}{0.9 * 1000 * \ (322)^2} = 1.72\text{MPa}$$

$$\rho = \frac{1}{17.6}\left(1 - \sqrt{1 - \frac{2 * 17.6 * 1.72}{420}}\right) = 0.00425$$

$A_s = \rho * b * d = 0.00425*1000*322 = 1369.95 \text{ mm}^2 /\text{m}$

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

$$= \frac{\sqrt{28}}{4 * 420} * 1000 * 322 \geq \frac{1.4}{420} * 1000 * 322$$

= 1014.2 mm^2 /m < 1073.3 mm^2 /m …. As, min = 1073.3 mm^2 /m

A_s = 1369.95 mm^2 > As, min = 1073.3 mm^2 **OK**

Use ϕ18/15cm …. As= 1696.46 mm^2 /m for Negative reinforcement

$\boldsymbol{A}_{\boldsymbol{s}_{provid}} = 1696.46$ mm2 /m $> \boldsymbol{A}_{\boldsymbol{s}_{req}} = 1369.95$ mm2 /m

- ✓ Maximum positive moment $Mu^{(+)}$ = 76.6 kN.m

$R_n = \frac{M_n}{0.9 * b * d^2} = \frac{76.6 * 10^6}{0.9 * 1000 * (322)^2}$ = 0.82 MPa

$\rho = \frac{1}{17.6}\left(1 - \sqrt{1 - \frac{2 * 17.6 * 0.82}{420}}\right)$ = 0.00199

As = ρ * b *d =0.0019*1000*322 = 611.8 mm2 /m

As = 1014.2 mm2 < As, min = 1073.3 mm2

➔ As, min = 1073.3 mm2 …. **control**

Use ϕ18/25cm …. As= 1272.3 mm^2 /m for Positive reinforcement

$\boldsymbol{A}_{\boldsymbol{s}_{provid}} = 1272.3$ mm2 /m $> \boldsymbol{A}_{\boldsymbol{s}_{req}} = 1073.3$ mm2 /m

- ✓ **Design for Shear**

- ✓ $(V_{u,d} = 191.4\ KN)$

$\phi Vc = \phi * \frac{\sqrt{f_c'}}{6} * b * d = 0.75 * \frac{\sqrt{28}}{6} *1000* 322 * 10^{-3} = 213$ KN.

$V_u \leq \phi V_c$

$191.4 < 213$

Thickness is ok …..

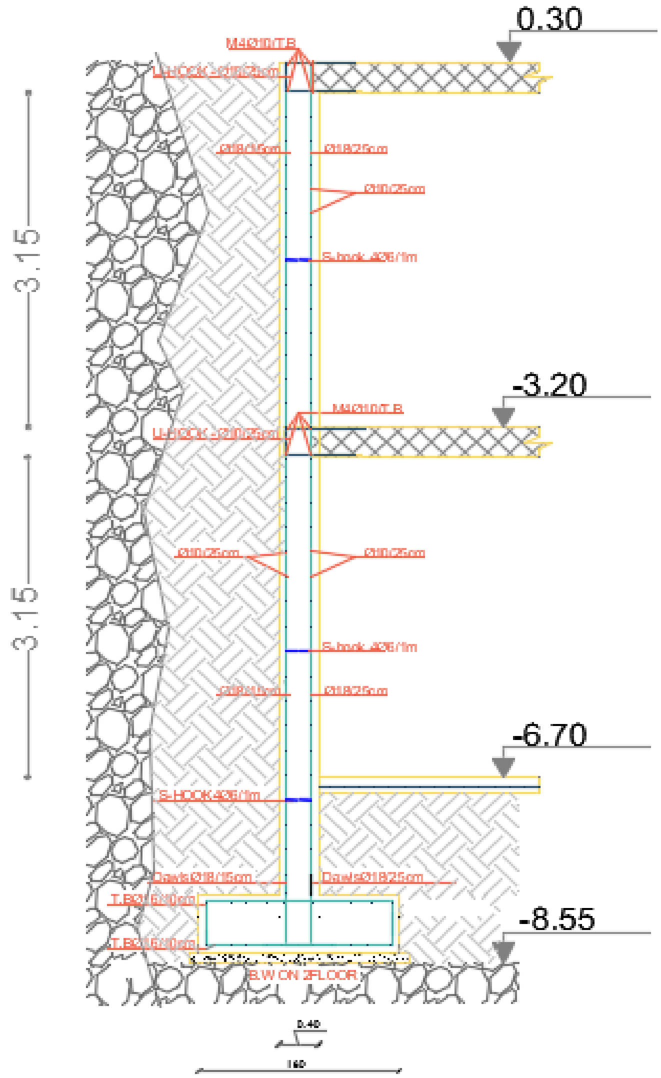


Figure 4-12 : Basement Wall detailing

4.11 Design of Footing (F1)

- ✓ **Material :-**

⇒ Concrete B350 Fc' = 28 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

- ✓ **Load Calculations**

Dead Load =4863.8 KN, Live Load = 2124.9 KN

Total services load = 4863.8+ 2124.9 = 6988.7 KN

Total Factored load = 1.2*4863.8 + 1.6*2124.9 = 9236.4 KN

Column Dimensions (a*b) =80*55 cm

Soil density = 17 Kg/cm3

Allowable Bearing Capacity = 450 Kn/m2

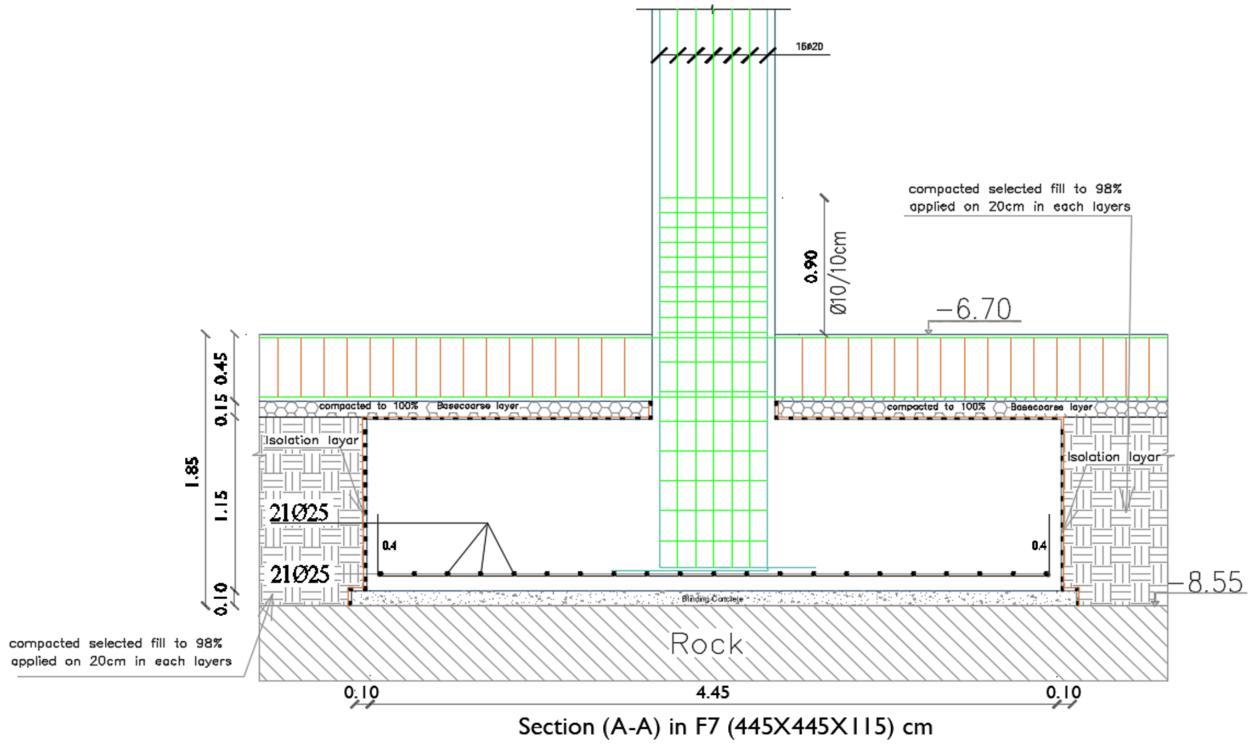


Figure 4-13: Footing F1 Section detailing

Assume h = 115 cm

$q_{net-allow}$ = 450 – (17*0.60 + 25*1.15 + 5) = 406

✓ Area of Footing :-

$$A = \frac{Pn}{q_{net-allow}} = \frac{6988.7}{406} = 17.21m^2$$

Assume Square Footing
B required =4.45 m
Select B = 4.45 m

✓ Bearing Pressure :-

q_u = 9236.4 /4.5*4.5 = 456.119 Kn/m^2

✓ Design of Footing:

4.11.1 Design of One-Way Shear Strength:

Critical Section at Distance (d) From The Face of Column

Assume h = 115 cm, bar diameter ø 25 for main reinforcement and 7.5 cm Cover

d = 1150– 75 – $\frac{25}{2}$ = 1062.5 mm

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

Vu = 456.119 $* \left(\frac{4.45-0.55}{2} - 1.0625\right) * 4.45$=1801.385kn

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

$$\varphi.Vc = 0.75 * \frac{1}{6} * \sqrt{28} * 4450 * 1062.5 = 3127.36Kn$$

$$\varphi.Vc = 3127.36KN > Vu = 1801.385Kn$$

$\therefore Safe$

4.11.2 Design of Two Way Shear Strength (punching shear):

Vu=Pu-FR_b

FR_b= q_u*area of critical section

Vu=456.119*(4.45*4.45-((0.8+1.0625) *(0.55+1.0625)) = 7662.443 Kn

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

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

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

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

Where:

$\beta_C = \frac{Column\ \ Length\ \ (a)}{Column\ \ Width\ \ (b)} = \frac{0.8}{0.55} = 1.4545$

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

$b_o = 2 * (0.8 + 1.0625) + 2 * (0.55 + 1.0625) = 6.95m$

α_s = 40 for interior column

$\varphi.V_C = \frac{1}{6}\left(1 + \frac{2}{\beta_c}\right) = \frac{1}{6} * \left(1 + \frac{2}{1.4545}\right) = 0.396$

$\varphi.V_C = \frac{1}{12}\left(\frac{\alpha_s * d}{b_o} + 2\right) = \frac{1}{12} * \left(\frac{40 * 1062.5}{6950} + 2\right) = 0.6763$

$\varphi.V_C = \frac{1}{3} = 0.333$ …. **control**

$$\varphi.V_C = \varphi.\frac{1}{3}\sqrt{f_c{}'}b_o d = \frac{0.75}{3} * \sqrt{28} * 6950 * 1062.5 * 10^{-3} = 9768.61$$

ΦVc =9768.61 Kn > Vu=7662.443 kn

4.11.3 Design for Flexure

Critical Section at the Face of Column

Mu = 456.119*4.45*1.95*1.95/2 = 3859Kn.m

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{3859\times10^6}{0.9\times4450\times1062.5^2} = 0.853 Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times28} = 17.65$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{17.65}\left(1-\sqrt{1-\frac{2\times17.65\times0.853}{420}}\right) = 0.0020687$

$A_{s,req}$ = ρ.b.d =0.0020687×4450×1062.5= 9781.072 mm^2

$A_{s,min}$ = 0.0018*4450*800= 6408 mm^2

$A_{s,req}$ = 9781.072 mm^2 > $A_{s,min}$ =6408 mm^2

As,req = 9781.072 mm2 ……… is control

n = $\frac{9781.072}{AS\ 25}$ **= 19.93**

<u>Use 21ø25in Both Direction</u>

Check for Spacing:

$S = \frac{\mathbf{4450-(75*2)-(25*25)}}{\mathbf{20}}$ **= 183.75**

S = 3h = 3*110 = 330cm

S = 45 cm ……… **is control**

Smax = 45 cm > S= 18.3cm → OK

4.11.4 Design of Dowels:

Load Transfer in Footing:

$$\Phi Pn.b = \Phi(0.85\, fc' A_1 \times \sqrt{\frac{A_2}{A_1}})$$

$A_1 = 0.8 * 0.55 = 0.44\ m^2$

$A_2 = 4.45 * 4.45 = 19.80\ m^2$

$$\sqrt{\frac{A_2}{A_1}} = \sqrt{\frac{19.80}{0.44}} = 6.71 > 2 \ldots\ldots\ldots\ldots\ldots \sqrt{\frac{A_2}{A_1}} = 2$$

$$\Phi Pn.b = 0.65 \times (0.85 \times fc \times A1 \times \sqrt{\frac{A_2}{A_1}})$$

$$\Phi Pn.b = 0.65 \times (0.85 \times 28 \times 440 \times 2) = 13613.6 Kn$$

$$\Phi Pn = 13613.6 > Pu = 9236.4 \ldots\ldots\ldots\ldots ok$$

As,min = 0.005*A1

= 0.005 * 440*1000

= 2200 m^2

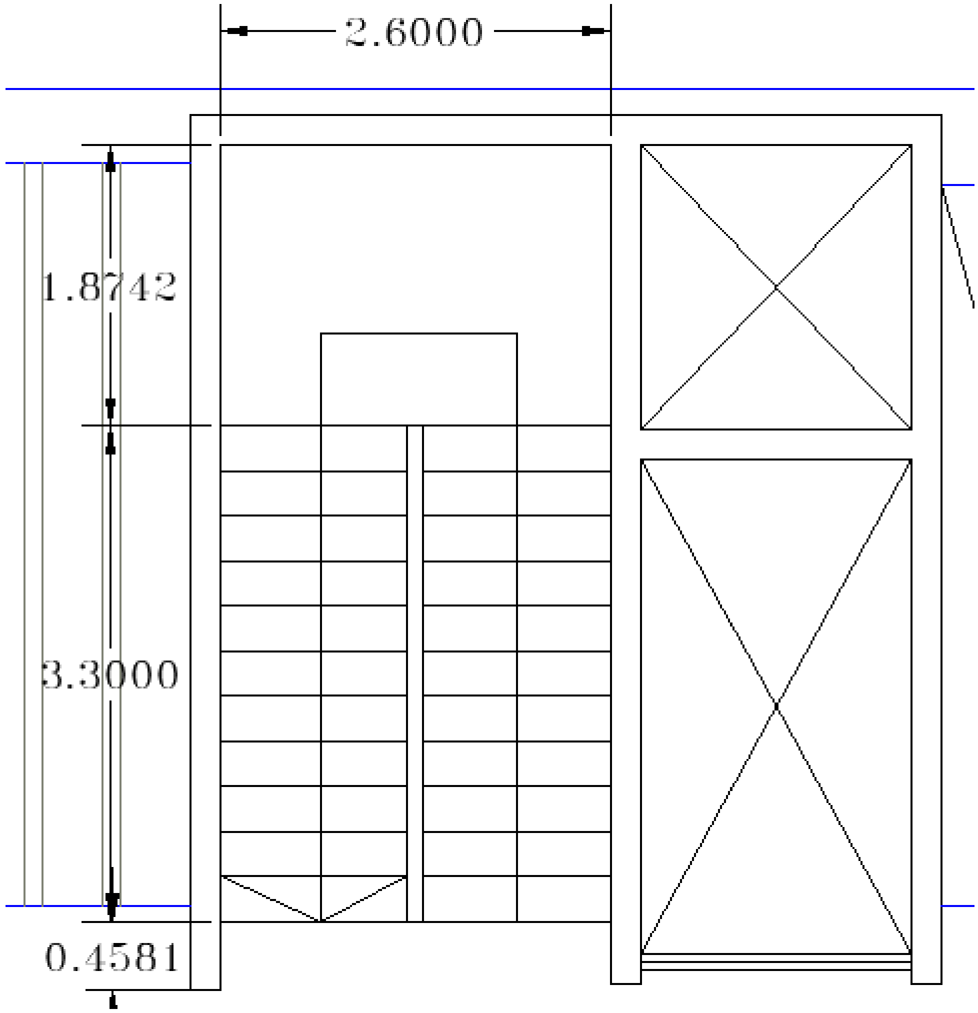
n $= \frac{2200}{AS\ 20}$ = 7.0028

Use 8 ø 20

As=2513.27 mm^2 > As,min = 2200 m^2

Select Dowels reinforcement 16 ø 20 Same # of Bars in columns.

4.12 Design of Stair



✓ Design of srair:

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

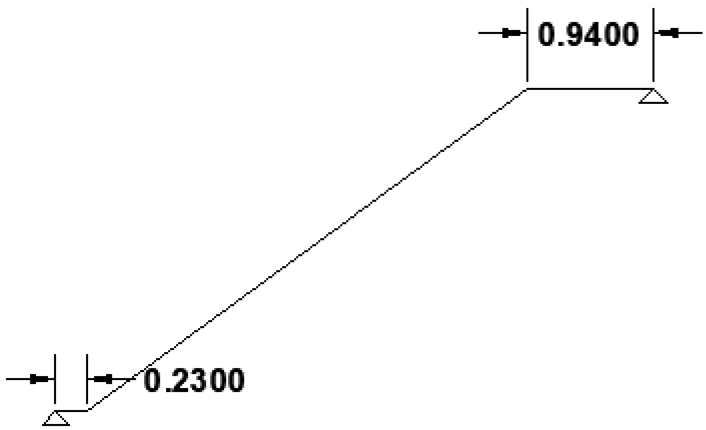
4.12.1 Design of Flight

h_{min} = L/20

h_{min} = 4.47/20 = 22 cm

Take h = 22 cm

The Stair Slope by $\theta = \tan^{-1}(164 / 330) = 26.6$



Figure(4- 14) Structural System

Dead load for flight for 1m strip:

No.	Material	Quality Density	DL (KN/m)
1	Tile	23	**23*0.03*1*((0.33+0.15)/0.3) = 1.1KN/m**
2	Mortar	22	**22*0.03*1*((0.3+0.15)/0.3) =0.99 KN/m**
3	C.R	25	**25*0.22*1 / cos 26.6= 6.2KN/m**
4	Plaster	22	**22*0.03*1 / cos 26.6=0.5KN/m**
5	**Stair**	25	**(25\0.3)*((0.15*0.3)\2) = 1.9 KN/m**

∑ =	**10.69**	**KN/m**

Table 4-4:Dead Load Calculation of Flight.

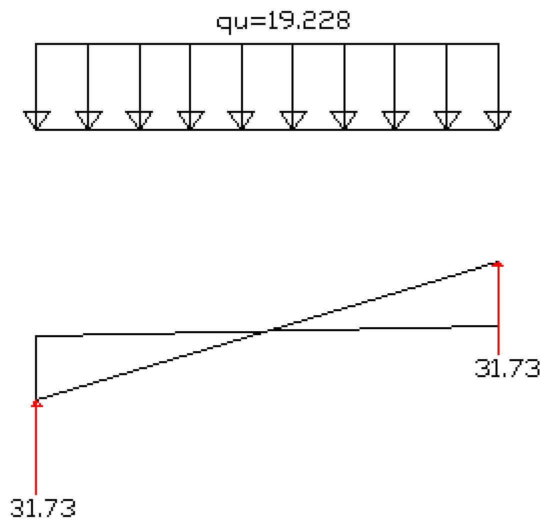
Factored Load for <u>Flight</u>:-

WU = 1.2 ×10.69+ 1.6×4= 19.228KN/m

Shear Force Diagram.

(qu/2) ×3.3 = (19.228/2) × 3.3= 31.73 kN.

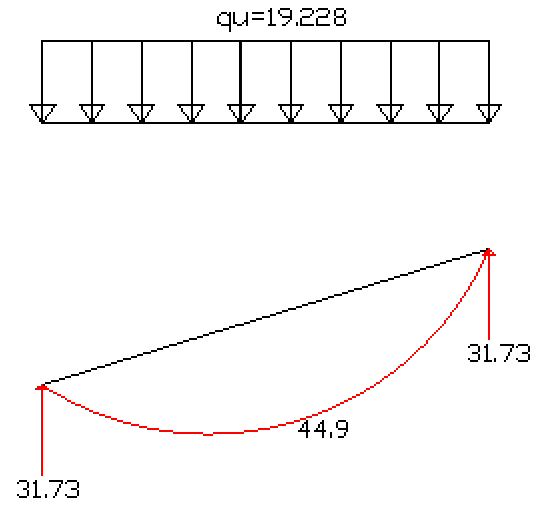
Max. Vu of Flight = 31.73$\mathbf{cos\ 26.6}$ = 28.37 kN



Figure(4- 15) Factored Load

Bending Moment Diagram.

Max. Mu of Flight = 31.73×2.24 – 19.228×1.65×0.825 = 44.9 kN.m



Figure(4- 16) Bending Moment Diagram

design of shear : (vu=28.37 kn)

Assume bar diameter ø 14 for main reinforcement.

d =h- cover $-\frac{d_b}{2} = 220 - 20 - \frac{14}{2} = 193\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d == \ \frac{1}{6}\sqrt{24} * 1000 * 193 = 157.079$ KN

$\Phi * V_c = 0.75 * 157.079 = 118.19$ Kn > Vu = 28.37 kn

$\frac{\Phi * Vc}{2}$ = 59.1 > Vu = 28.37 kn …... **No shear reinforcement is required.**

Design of bending moment : (mu=44.9 kn.m)

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

d = depth - cover – (diameter of bar/ 2)
=220 – 20 – 14/2 = 193 mm

$R_n = \frac{M_n}{0.9*b*d^2} = \frac{44.9 \ *10^6}{0.9*1000*(193)^2}$ = 1.339 MPa

$$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*1.339}{420}}\right) = 0.0033$$

As = ρ * b *d =0.0033*1000*193 = 636.9 mm2 /m

As,min = 0.0018*1000*220= 396 mm2

As,req = 636.9 mm2 > As,min =396 mm2

As,req = 636.9 mm2 ……… is control

Check for Spacing:

Smax = 3h = 3*250 =750 mm

Smax = 450 mm

Smax = 300mm ……… is control

S=200mm < 300 …. Ok

∴ Select Ø14/200 mm with As = 769.69 mm2 > As req= 636.9 mm2 …. For Main Reinforcement

Check For Strain:

$$a = \frac{As,req*fy}{0.85*b*f\acute{c}} = \frac{450*420}{0.85*1000*24} = 9.26 \text{ mm}$$

$$c = \frac{a}{0.85} = 10.9\text{mm}$$

$\varepsilon s = 0.003 \times (\frac{d-c}{c}) = 0.003 \times (\frac{193-10.9}{10.9}) = 0.0501 > 0.005$ ………. $Ø = 0.9$ (OK)

✓ Shrinkage and Temperature

$$n = \frac{Asmin}{As,10} = \frac{360}{As,10} = 4.6$$

$$s = \frac{100}{5} = 20$$

Check for spacing:

S = 5h = 5*220 = 1100 mm

S = 450 mm ……… **is control**

Smax = 45 cm > S= 20 cm ---- OK

Use ϕ10/20 cm...... Or 5 ϕ10

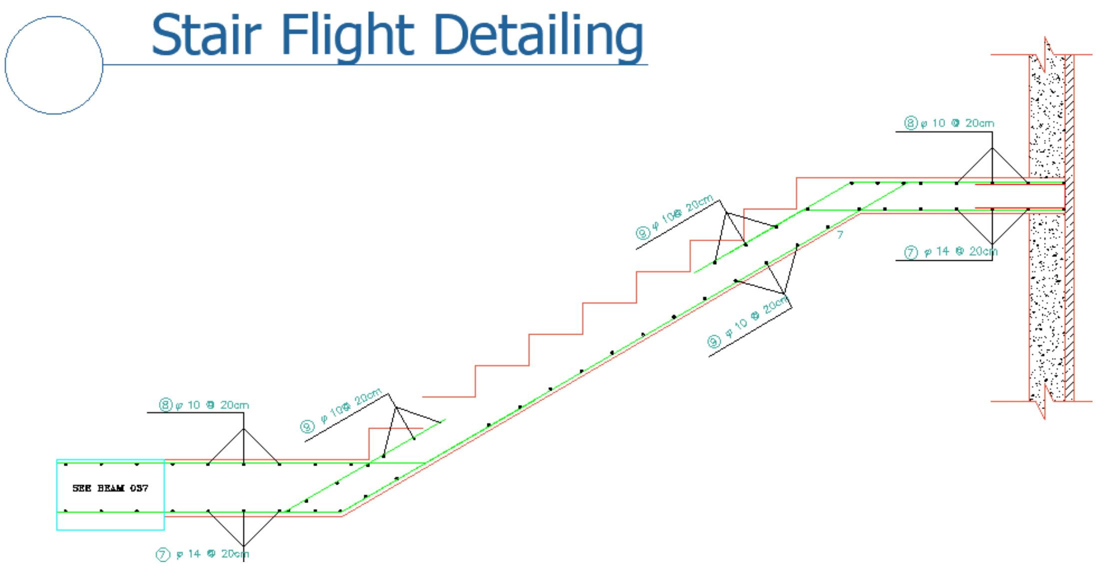


Figure 4-1: Stair flight detailing

- **Design of Middle Landing**

Dead load for landing for 1m strip

No.	Material	Quality Density KN/m3	DL (KN/m)		
1	Tile	23	**23*0.03*1= 0.7KN/m**		
2	Mortar	22	**22*0.03*1= 0.66KN/m**		
3	C.R	25	**25*0.22*1= 5.5KN/m**		
4	Plaster	22	**22*0.02*1= 0.44KN/m**		
5	Sand	17	**0.07*17*1=1.19**		
			∑ =	**8.49**	**KN/m**

Table 4-5: Dead Load Calculation of strip.

Factored load for landing:

WU = 1.2 ×8.49+ 1.6×4 = 16.6 KN/m

Vu=21.58-(16.6(0.13+.224)=15.7 KN

Mu=$\frac{qu*l^2}{8} = \frac{16.6*3.3^2}{8} = 22.6$ KN/m

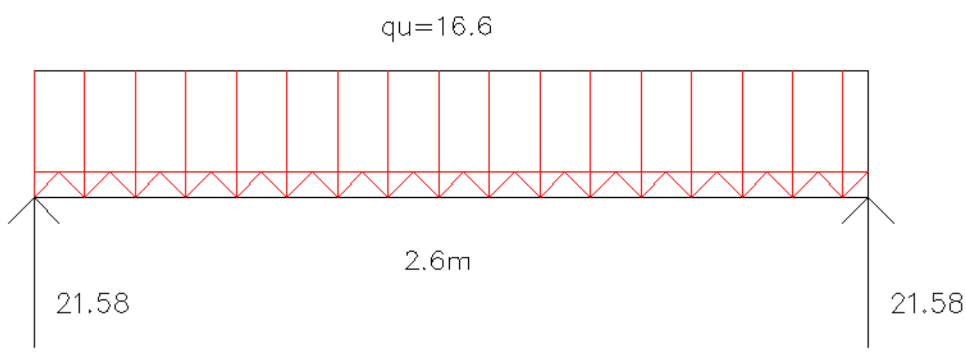


Figure 4-18: Dead Load strip.

✓ design of Shear:- (Vu=15.7 kn)

Assume bar diameter ø 14 for main reinforcement d =h- cover $-\frac{d_b}{2} = 220 - 20 - \frac{14}{2} = 193\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d == \frac{1}{6}\sqrt{24} * 1000 * 193 = 157.583$ KN

$\Phi * V_c = 0.75 * 157.583 = 118.19$ Kn > Vu = 215.7 kn

$\frac{\Phi * Vc}{2} = 52.95 >$ Vu = 15.7 kn **…... No shear reinforcement are required**

- ✓ **Design of Bending Moment:- (Mu=22.6 KN.m)**

$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.6$

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

$= 220 - 20 - \frac{12}{2} = 194$ mm

$R_n = \frac{M_n}{0.9 * b * d^2} = \frac{25.11 \ * 10^6}{0.9 * 1000 * (194)^2} = 0.667$ MPa

$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 20.6 * 0.667}{420}}\right) = 0.00161$

$A_s = \rho * b * d = 0.00161 * 1000 * 194 = 312.34\ m^2$ /m

$A_{s,min} = 0.0018 * 1000 * 220 = 396\ mm^2$

$A_{s,req} = 396\ mm^2 < A_{s,min} = 312.34\ mm^2$

As,req = 396 mm2 ……… is control

$n = \frac{As,req}{As,12} = 3.5$

$s = \frac{100}{5} = 20$

Check for Spacing:-

Smax = 3h = 3*220 =660 mm

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

Smax < 300*($\frac{280}{\frac{2}{3}*420}$) – 2.5*20 = 300 ……. cont

Smax = 450 mm

Smax = 300mm **……… is control**

S=200 mm < 300 …. OK

Use ϕ12/20 cm …. Or 4 ϕ12

$A_{s_{provid}} = 452.4 \text{ mm2 /m } > A_{s_{req}} = 396\text{mm2 /m}$

Check For Strain:

a = $\frac{As,req*fy}{0.85*b*fć} = \frac{396*420}{0.85*1000*28}$ = 9.26 mm

c = $\frac{a}{0.85}$ = 10.9mm

εs = 0.003 × ($\frac{d-c}{c}$) = 0.003 × ($\frac{194-10.9}{10.9}$) = 0.0504 > 0.005 ………. Ø = 0.9 (OK)

- ✓ **Shrinkage and Temperature**

$n = \frac{Asmin}{As,10} = \frac{360}{As,10} = 4.6$

$s = \frac{100}{5} = 20$

Check for Spacing :-

S = 5h = 5*200 = 1000 mm

S = 450 mm **……… is control**

Smax = 45 cm > S= 20 cm OK

Use ϕ10/20 cm …. Or 5 ϕ10

4.12.1 Design of Middle Landing

Take h = 22 cm

No.	Material	Quality Density KN/m3	DL (KN/m)	
1	Tile	23	**23*0.03*1= 0.7KN/m**	
2	Mortar	22	**22*0.03*1= 0.66KN/m**	
3	C.R	25	**25*0.22*1= 5KN/m**	
4	Plaster	22	**22*0.02*1= 0.44KN/m**	
			$\sum =$ **7.3**	**KN/m**

Table 4-6: Dead Load Calculation for Landing for 1m Strip of Middle Landing

Factored Load for Landing: -

W_U = 1.2 ×7.3+ 1.6×4 = 15.16 KN/m

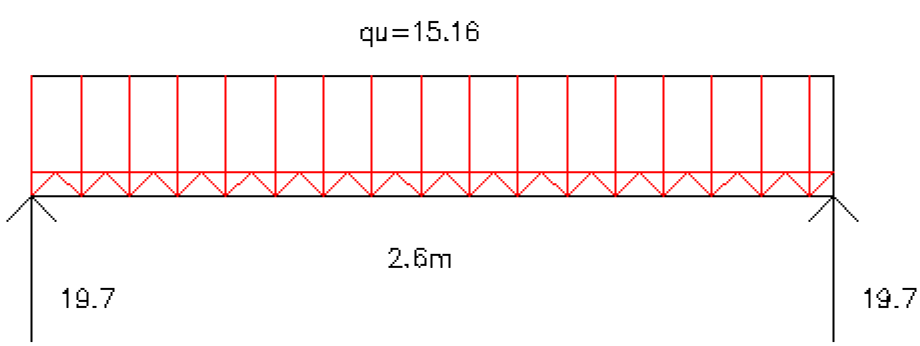


Figure 4-19: Reactions of Middle Landing

R = $\frac{21.49}{1.35}$ = 16 kN/m

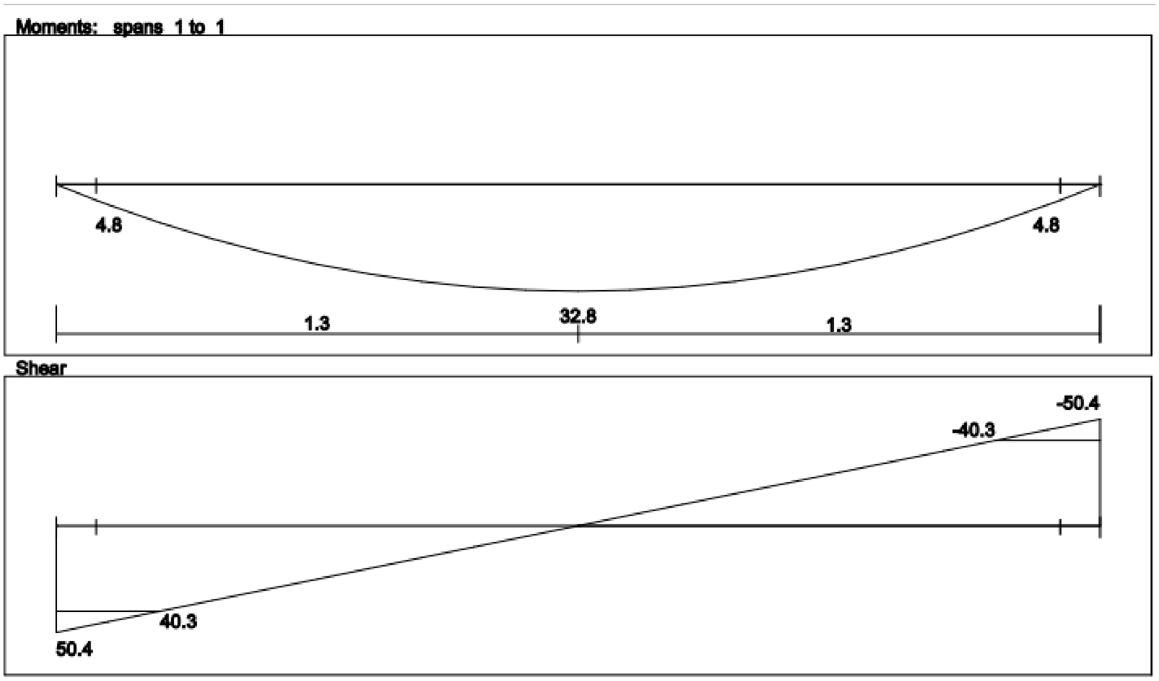


Figure 4-20:Load & Moment Envelope & Shear Envelope diagram for Middle Landing

✓ design of Shear:- (Vu=40.3 kn)

Assume bar diameter ø 14 for main reinforcement

d =h- cover $-\frac{d_b}{2} = 220 - 20 - \frac{14}{2} = 193\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d == \ \frac{1}{6}\sqrt{24} * 1000 * 193 = 157.583$ KN

$\Phi * V_{c\,=}$ 0.75* 157.583 = 118.19Kn > Vu = 40.3 kn

$\frac{\Phi * Vc}{2}$ = 59.1 > Vu = 40.3 kn **…... No shear reinforcement are required**

✓ Design of Bending Moment:- (Mu=32.8 KN.m)

m = $\frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.6$

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

$=220 - 20 - \frac{14}{2} = 193$ mm

$R_n = \frac{M_n}{0.9*b*d^2} = \frac{32.8 \quad *10^6}{0.9*1000*\ (193)^2} = 0.98$ MPa

$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*0.98}{420}}\right) = 0.00239$

$A_s = \rho * b *d = 0.00239*1000*193 = 461.27\ m^2$ /m

$A_{s,min} = 0.0018*1000*220 = 396\ mm^2$

$A_{s,req} = 461.27\ mm^2 \quad > A_{s,min} = 396\ mm^2$

As,req = 461.27 mm2 ……… is control

$n = \frac{As,req}{As,14} = 3$

$s = \frac{100}{5} = 20$

Check for Spacing:-

Smax = 3h = 3*220 =660 mm

Smax = $380*(\frac{280}{\frac{2}{3}*420}) - 2.5*20 = 330$

Smax < $300*(\frac{280}{\frac{2}{3}*420}) - 2.5*20 = 300$ ……. cont

Smax = 450 mm

Smax = 300mm **……… is control**

S=200 mm < 300 …. OK

Use ϕ14/20 cm …. Or 3 ϕ14

$\boldsymbol{A_{s_{provid}}} = 461.8$ mm2 /m $> \boldsymbol{A_{s_{req}}} = 461.27$mm2 /m

✓ Shrinkage and Temperature

$n = \frac{\text{Asmin}}{\text{As,10}} = \frac{360}{\text{As,10}} = 4.6$

$s = \frac{100}{5} = 20$

Check for Spacing :-

S = 5h = 5*200 = 1000 mm

S = 450 mm **……… is control**

Smax = 45 cm > S= 20 cm OK

Use ϕ10/20 cm …. Or 5 ϕ10

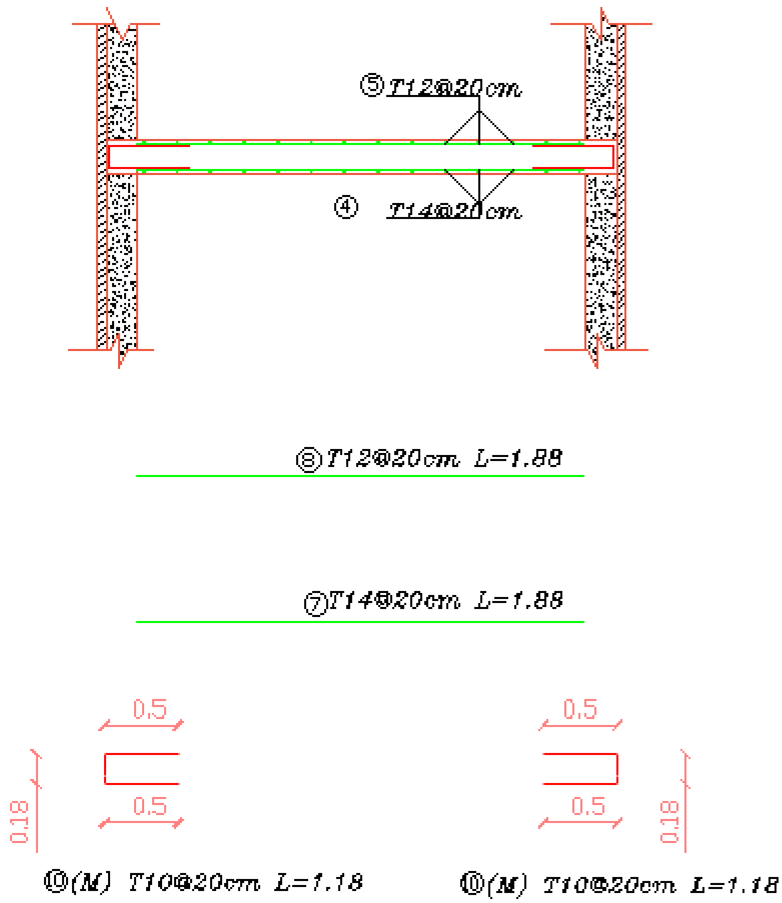


Figure 4-2:Middle Landing detailing

4.13 Seismic Design

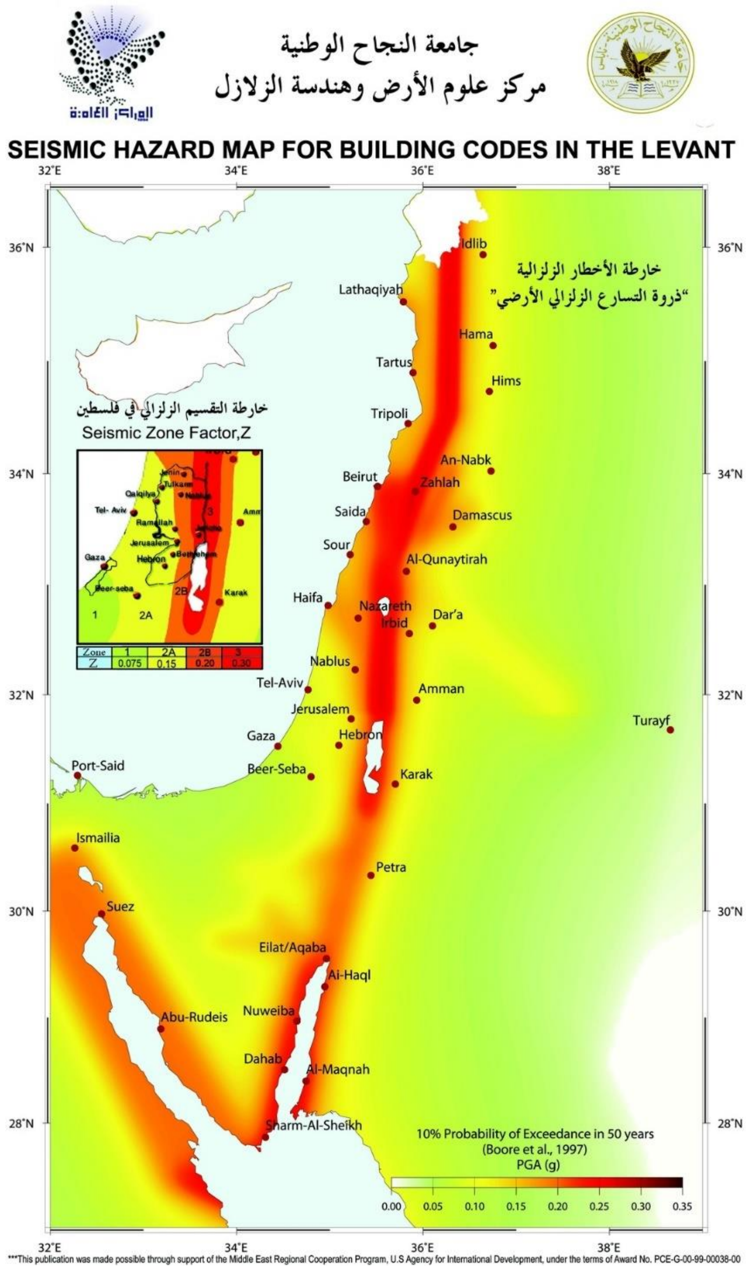


Figure 4-3 : Seismic Hazard Map For Building Codes in Palestine

So based on in these map Hebron in zone 2A and we selected Z=0.15

Ss= 2.5 * Z = 2.5 * 0.15 = 0.375

S1= 1.25 * Z = 1.25 * 0.15 = 0.186

The Value On Etabs

Ss = 0.375 * 1.5 = 0.56

S1= 0.186 * 1.5 = 0.28

✓ Select Site Class

Table 20.3-1 Site Classification

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard rock	>5,000 ft/s	NA	NA
B. Rock	2,500 to 5,000 ft/s	NA	NA
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50 blows/ft	>2,000 lb/ft^2
D. Stiff soil	600 to 1,200 ft/s	15 to 50 blows/ft	1,000 to 2,000 lb/ft^2
E. Soft clay soil	<600 ft/s	<15 blows/ft	<1,000 lb/ft^2
	Any profile with more than 10 ft of soil that has the following characteristics: — Plasticity index $PI > 20$, — Moisture content $w \geq 40\%$, — Undrained shear strength $\bar{s}_u < 500$ lb/ft^2		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

Note: For SI: 1 ft = 0.3048 m; 1 ft/s = 0.3048 m/s; 1 lb/ft^2 = 0.0479 kN/m^2.

Table 4-1 : Site Classification (Table 20.3-1 from ASCE 7-16)

The Rook in Hebron is a Lame stone.

So the Velocity of Waves = 3000 m/s = 9800 ft/s

So Site Class A. Hard rock.

Select Ct and X form Table

Table 12.8-2 Values of Approximate Period Parameters C_t and x

Structure Type	C_t	x
Moment-resisting frame systems in which the frames resist 100% of the required seismic force and are not enclosed or adjoined by components that are more rigid and will prevent the frames from deflecting where subjected to seismic forces:		
Steel moment-resisting frames	0.028 (0.0724)[a]	0.8
Concrete moment-resisting frames	0.016 (0.0466)[a]	0.9
Steel eccentrically braced frames in accordance with Table 12.2-1 lines B1 or D1	0.03 (0.0731)[a]	0.75
Steel buckling-restrained braced frames	0.03 (0.0731)[a]	0.75
All other structural systems	0.02 (0.0488)[a]	0.75

[a]Metric equivalents are shown in parentheses.

Table 4-2 : Values of Approximate Period Parameters Ct & X (Table 12.8-2 from ASCE 7-16)

So, → C_t = 0.02

→ X=0.75

✓ Select Fa in Table 11.4 – 1

Table 11.4-1 Short-Period Site Coefficient, F_a

Site Class	Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at Short Period					
	$S_S \leq 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S = 1.25$	$S_S \geq 1.5$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8
F	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8

Note: Use straight-line interpolation for intermediate values of S_s.

Table 4-3: Short-Period Site Coefficient Fa (Table 11.4-1 from ASCE 7-16)

In Ss = 0.56, → Fa = 0.8

✓ **Select Fv in Table 11.4-2**

Table 11.4-2 Long-Period Site Coefficient, F_v

Site Class	Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at 1-s Period					
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 = 0.5$	$S_1 \geq 0.6$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2[a]	2.0[a]	1.9[a]	1.8[a]	1.7[a]
E	4.2	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8
F	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8

Note: Use straight-line interpolation for intermediate values of S_1.
[a] Also, see requirements for site-specific ground motions in Section 11.4.8.

Table 4-4: Long-Period Site Coefficient Fv (Table 11.4-2 from ASCE 7-16)

In S_1= 0.28, → Fa = 0.8

Calculate SDS , SD1

SDS = Fa Ss = 0.8 * 0.56 = 0.448

SD1 = Fv S_1 = 0.8 * 0.28 = 0.224

In Etabs.

SDS = $\frac{2}{3}$ * 0.448 = 0.298

SD1 = $\frac{2}{3}$ * 0.224 = 0.149

✓ Select Risk Category.

TABLE 1604.5 RISK CATEGORY OF BUILDINGS AND OTHER STRUCTURES

RISK CATEGORY	NATURE OF OCCUPANCY
I	Buildings and other structures that represent a low hazard to human 'ife in the event of failure, including but not limited to: • Agricultural facilities. • Certain temporary facilities. • Minor storage facilities.
II	Buildings and other structures except those listed in Risk Categories I, III and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures containing elementary school, secondary school or day care facilities with an occupa load greater than 250. • Buildings and other structures containing adult education facilities, such as colleges and universities, with an occupant load greater than 500. • Group I-2 occupancies with an occupant load of 50 or more resident care recipients but not having surgery or emergency treatment facilities. • Group I-3 occupancies. • Any other occupancy with an occupant load greater than 5,000[a]. • Power-generating stations, water treatment facilities for potable water, waste water treatment facilities and other public utility facilities not included in Risk Category IV. • Buildings and other structures not included in Risk Category IV containing quantities of toxic or explosive materials that: Exceed maximum allowable quantities per control area as given in Table 307.1(1) or 307.1(2) or per outdoor control area in accordance with the *International Fire Code*; and Are sufficient to pose a threat to the public if released[b].
IV	Buildings and other structures designated as essential facilities, including but not limited to: • Group I-2 occupancies having surgery or emergency treatment facilities. • Fire, rescue, ambulance and police stations and emergency vehicle garages. • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response. • Power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures. • Buildings and other structures containing quantities of highly toxic materials that: Exceed maximum allowable quantities per control area as given in Table 307.1(2) or per outdoor control area in accordance with the *International Fire Code*;

Table 4-5: Risk Category (Table 1604.5 from ASCE 7-16)

→ R = 3

✓ Select Seismic Design Category.

TABLE 11.6-1 Seismic Design Category Based on Short-Period Response Acceleration Parameter

Value of S_{DS}	Risk Category I or II or III	Risk Category IV
$S_{DS} < 0.167$	A	A
$0.167 \le S_{DS} < 0.33$	B	C
$0.33 \le S_{DS} < 0.50$	C	D
$0.50 \le S_{DS}$	D	D

Table 4-6 : Seismic Design Category Based on Sort-Period (Table 11.6-5 from ASCE 7-16)

In SDS = 0.3 → Risk Category: B

TABLE 11.6-2 Seismic Design Category Based on 1-s Period Response Acceleration Parameter

Value of S_{D1}	Risk Category I or II or III	Risk Category IV
$S_{D1} < 0.067$	A	A
$0.067 \le S_{D1} < 0.133$	B	C
$0.133 \le S_{D1} < 0.20$	C	D
$0.20 \le S_{D1}$	D	D

Table 4-7 : Seismic Design Category Based on 1-s Period (Table 11.6-5 from ASCE 7-16)

In SD1 = 0.15 → Risk Category: C

Select Seismic Design Category worst case C

✓ **Select Seismic Importance Factor.**

Table 1.5-2 Importance Factors by Risk Category of Buildings and Other Structures for Snow, Ice, and Earthquake Loads

Risk Category from Table 1.5-1	Snow Importance Factor, I_s	Ice Importance Factor—Thickness, I_i	Ice Importance Factor—Wind, I_w	Seismic Importance Factor, I_e
I	0.80	0.80	1.00	1.00
II	1.00	1.00	1.00	1.00
III	1.10	1.15	1.00	1.25
IV	1.20	1.25	1.00	1.50

Note: The component importance factor, I_p, applicable to earthquake loads, is not included in this table because it depends on the importance of the individual component rather than that of the building as a whole, or its occupancy. Refer to Section 13.1.3.

Table 4-8 : Seismic Importance Factor (Table 1.5-2 from ASCE 7-16)

In R=3 → I_e = 1.25

✓ Select Seismic Force-Resisting System

Seismic Force-Resisting System	ASCE 7 Section Where Detailing Requirements Are Specified	Response Modification Coefficient, R^a	Overstrength Factor, $\Omega_0{}^b$	Deflection Amplification Factor, $C_d{}^c$	Structural System Limitations Including Structural Height, h_n (ft) Limits[d] — Seismic Design Category: B	C	D[e]	E[e]	F[f]
B. BUILDING FRAME SYSTEMS									
1. Steel eccentrically braced frames	14.1	8	2	4	NL	NL	160	160	100
2. Steel special concentrically braced frames	14.1	6	2	5	NL	NL	160	160	100
3. Steel ordinary concentrically braced frames	14.1	3¼	2	3¼	NL	NL	35[j]	35[j]	NP[j]
4. Special reinforced concrete shear walls[g,h]	14.2	6	2½	5	NL	NL	160	160	100
5. Ordinary reinforced concrete shear walls[g]	14.2	5	2½	4½	NL	NL	NP	NP	NP
6. Detailed plain concrete shear walls[g]	14.2 and 14.2.2.7	2	2½	2	NL	NP	NP	NP	NP

Table 4-9 : Design coefficients & Factors for Seismic Force-Resisting System (Table 12.2-1 from ASCE 7-16)

Design coefficients & Factors for Seismic Force-Resisting System

In Our Region Ordinary reinforced concrete shear Wall, Because in Hebron Not Active in Earthquake.

$R = 5$ $\Omega = 2.5$ $C_d = 4.5$

Select Permitted Analytical Procedures :

Table 12.6-1 Permitted Analytical Procedures

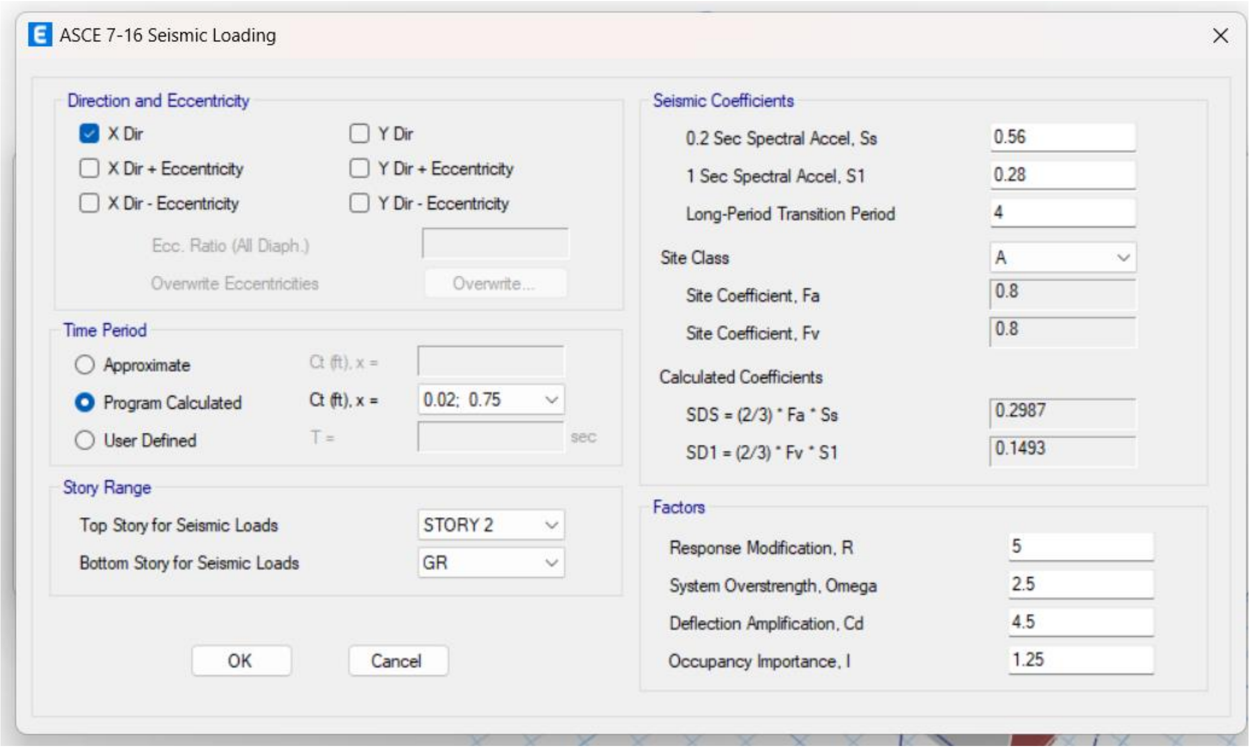
Seismic Design Category	Structural Characteristics	Equivalent Lateral Force Procedure, Section 12.8[a]	Modal Response Spectrum Analysis, Section 12.9.1, or Linear Response History Analysis, Section 12.9.2[a]	Nonlinear Response History Procedures, Chapter 16[a]
B, C	All structures	P	P	P
D, E, F	Risk Category I or II buildings not exceeding two stories above the base	P	P	P
	Structures of light-frame construction	P	P	P
	Structures with no structural irregularities and not exceeding 160 ft (48.8 m) in structural height	P	P	P
	Structures exceeding 160 ft (48.8 m) in structural height with no structural irregularities and with $T < 3.5T_s$	P	P	P
	Structures not exceeding 160 ft (48.8 m) in structural height and having only horizontal irregularities of Type 2, 3, 4, or 5 in Table 12.3-1 or vertical irregularities of Type 4, 5a, or 5b in Table 12.3-2	P	P	P
	All other structures	NP	P	P

[a]P: Permitted; NP: Not Permitted; $T_s = S_{D1}/S_{DS}$.

Table 4-10 : Permitted Analytical Procedures (Table 12.6-1 from ASCE 7-16)

In Seismic Design Category (C) Equivalent Lateral Force Procedure.

✓ Add The Value on Etabs ...



CHAPTER 5
" RECOMMENDATIONS and REFERENCES "

5.1 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.

5.2 Results:

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

1. The most important step before starting a design is to study the architectural plans carefully to distribute the columns correctly.
2. Gaining experience in using structural programs cannot be reached without an understanding of basic concepts of the structural design.
3. 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.

5.3 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.

5.4 References:

- كود البناء الأردني، كود الأحمال والقوى، عمان، الأردن: مجلس البناء الوطني الأردني 2006 م
- Building code requirements for structural concrete ACI-318-19
- ASCE 7-16
- الخارطة الزلزالية - جامعة النجاح الوطنية