Palestine Polytechnic University

College of Engineering

Civil Engineering Department

Graduation Project

" Structural design of a Alahd Hotel building. "

Project Team:

Ahmad Abd-Almutaleb Tamimi

Ismail Jamil Abu-Dawod

Osama Nezam Qawasma

Supervisor:

Eng. Inas Shwaki

Hebron-Palestine

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This project Submitted to the College of Engineering in partial fulfillment of the requirements for the degree of bachelor's degree in civil engineering Branch of Building Engineering.

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Signature of Project Supervisor

Name……………………………

Signature of Department Chairman

Name ………………………………..

الإهداء

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

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 دعاؤها 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

يا صاحب القلب الكبير نجوم أهتدي بها اليوم وفي الغد وإلى الأبد

..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 على

فريق المشروع

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Special thanks to our supervisor, Eng. Inas Shwaki made an effort to encourage us to do a great job, providing our team with valuable information and advice to be better every time. We thank you for the constant support and pleasant communication, which greatly affects our feeling of interest in what we are working on, who was the guiding light every step of the way we worked on this project.

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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.

ABSTRACT

The proposed project included the study and structural design of an Alahd hotel, and the safe structural design of a hotel consists of eight stories, two below ground and five above ground, with reception, parking, rooms, a sports club, and service floors.

Based on 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, beams, slabs, walls, and foundations, and determining the locations of the expansion joints, as this project contains many activities, which caused a challenge in distributing the columns and determining their locations, which affected the distribution and design of the slabs and beams. There were large distances between the columns, which affected the column loads, and caused the presence of bases of several types and large dimensions.

The results of this work resulted in a structural design that meets the standards.

ACI 318 Structural Design Code.

الملخص

تم هذا العمل بحمد الله وفضله من الطلبة:

- احمد عبد المطلب ابورجب التميمي
- اسامه نظام قواسمه
- إسماعيل جميل ابوداود

بإشراف المهندسة: ايناس شويكي

وقد تم في هذا المشروع إيجاد وحل التصميم الإنشائي الآمن لفندق العهد، والذي يتكون من ثمانية طوابق، اثنين تحت الأرض وست فوق الأرض، بحيث يحتوي على مكتب استقبال، وموقف سيارات ، وغرف ، ونادي رياضي ، وطابق خدمات.

ونظراً لكبر مساحة المشروع واجهنا العديد من التحديات الإنشائية، أهمها توزيع النظام الإنشائي من أعمدة، وكمرات، وألواح، وجدران، وأساسات، وتحديد مواقع فواصل التمدد، حيث إن هذا المشروع يحتوي على العديد من الأنشطة مما شكل تحديا في توزيع الأعمدة وتحديد مواقعها مما أثر على توزيع وتصميم البلاطات والجسور وجود مسافات كبيرة بين الأعمدة مما أثر على أحمال الأعمدة وتسبب في وجود قواعد بعدة أنواع وأبعاد كبيرة.

فتم استخدام حلول آمنة واقتصادية، مثل اختيار أنواع القعدات المناسبة للنظام الإنشائي

ومن خلال النتائج تم إنتاج تصميم إنشائي يلبي متطلبات كود التصميم الإنشائي ACI 318 وطلبات المالك ومتطلبات السلامة أيضا، ومتطلبات الجمال المعماري للفندق.

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LIST OF ABBREVIATIONS

- **Ac =** area of concrete section resisting shear transfer.
- **As =** area of non-prestressed tension reinforcement.
- **A_s`=** area of non-prestressed compression reinforcement.
- **Ag =** gross area of section.
- **Av =** area of shear reinforcement within a distance (S).
- **At =** area of one leg of a closed stirrup resisting tension within a (S).
- **b =** width of compression face of member.
- **bw =** web width, or diameter of circular section.
- **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.
- **Ec =** modulus of elasticity of concrete.
- **f_c`** = compression strength of concrete.
- **fy** = specified yield strength of non-prestressed reinforcement.
- **h =** overall thickness of member.
- **Ln =** 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.
- **Lw =** length of wall.
- **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.
- **W** = width of beam or rib.
- **Wu** = 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 PROJECT PROBLEM.

1.4 WORK PROCEDURE.

1.5 PROJECT SCOPE.

1.6 TIME LINE.

1.7 PROGRAMS USED IN THE PROJECT

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:

Obtaining experience in solving the problems of each project in particular.

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.

Gaining experience in reaching the best safe and economical design.

Using structural design programs and coMParing them with theoretical solutions.

1.3 PROJECT PROBLEM

In this project, we face challenges with the structural system so the main problem is the distribution structural system, do we solve this problem through the distribution of the columns to be suitable for architectural function, then we put the ribs on beams to transfer the load on columns then the load transfer to the foundation and after that to soil moreover we take care about this system to be more safety and more economy

1.4 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. was appreciated.
5. Analysis and design of the elements according to the ACI code using software and theoretical solutions.
6. Preparing construction drawings for all the elements in the building.
7. Writing a project where all these stages are presented in detail.

1.5 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 of all structural elements.

CHAPTER 5: Results and Recommendations.

1.6 TIME LINE

Section	Activity	D.Start	Duration	D.Finish
1	Project Selection.	20/2/2023	20 days	12/3/2023
1.1	Search for architectural plans.	13/3/2023	7 days	20/3/2023
1.2	Study the project plan.	21/3/2023	13 days	3/4/2023
2	Structural elements study.	4/4/2023	20 days	24/4/2023
2.1	Study columns.	25/4/2023	16 days	11/5/2023
2.2	slabs plans.	12/5/2023	7 days	19/5/2023
3	structural design.	20/5/2023	132	20/1/2024
3.1	slabs design.	20/5/2023	2 days	22/5/2023
3.2	Beams design.	23/5/2023	2days	25/5/2023
3.3	columns design.	10/9/2023	23 days	3/10/2023
3.4	walls design.	3/10/2023	25 days	28/10/2023
3.5	Foundations design.	29/10/2023	26 days	24/11/2023
4	Finishing the project.	25/11/2023	20 days	15/12/2023
4.1	Preparing the final blueprints.	16/12/2023	19 days	4/1/2024
4.2	Preparing the project book.	5/1/2024	15 days	20/1/2024

Figure 1-1 : Time Line

1.7 PROGRAMS USED IN THE PROJECT

1. Using analysis and structural design programs such as (Atir18, CSI Safe, CSI Etabs, Quick Footing 5, SpColumns)
2. Other programs such as Microsoft office Word, Power Point, Excel.
3. AutoCAD.

CHAPTER 2
" ARCHITECTURAL DESCRIPTION "

2.1 INTRODUCTION.

2.2 GENERAL IDENTIFICATION OF THE PROJECT.

2.3 GENERAL SITE DESCRIPTION.

2.4 FLOORS DESCRIPTION.

2.5 ELEVATIONS DESCRIPTION.

2.1 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

The Parking floor is a car park with an area of 3298 m2.

Basement, an area of 2490 m2, is a service floor containing a restaurant, a gym, and a swimming pool.

The ground floor, with an area of 2490 m2, contains a reception, restaurant, and administration.

The first floor of 2695 m2 consists of hotel rooms.

The second floor of 2695 m2 is a service floor with a low height of 2.1m.

The third and fourth floors with an area of 2190 square meters are hotel rooms.

2.3 GENERAL SITE DESCRIPTION:

The project is in:

Governorate: Hebron

City: Halhul

Location: Ain Shama

Basin: 30

Neighborhood: 3

Area: 26500 m2

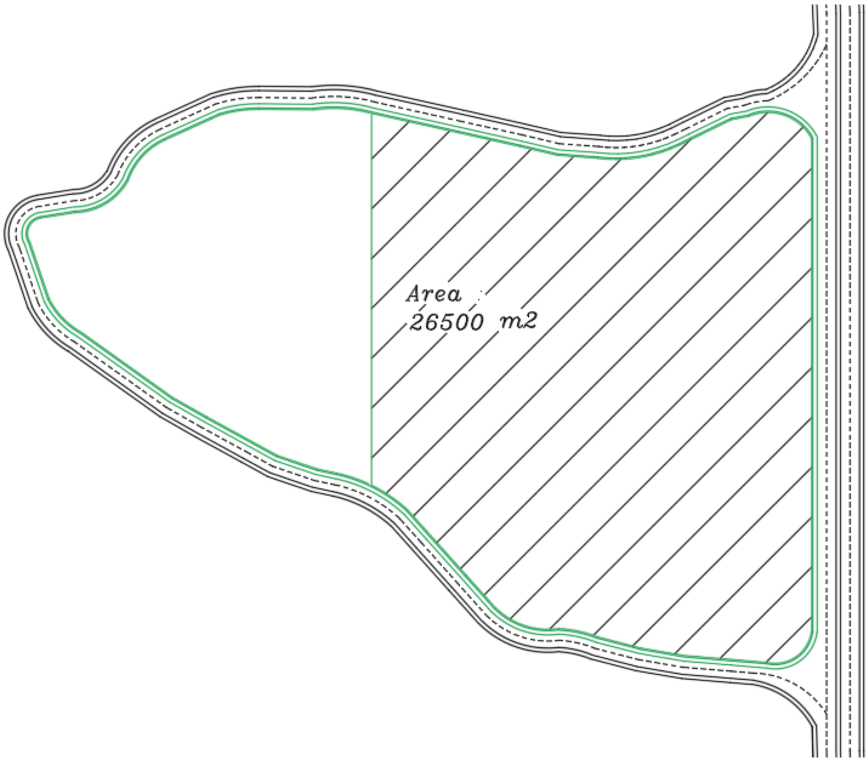


Figure 2-1: the project site, showing its shape and area.

Figure 2-2: the project site, showing its shape and area

2.4 FLOORS DESCRIPTION

2.4.1 Parking Floor:

(Level – 6.50 m) with an area of 3298 m2.

The parking floor consists of parking area for (74 cars), with service area consists of storage room and pool maintenance room.

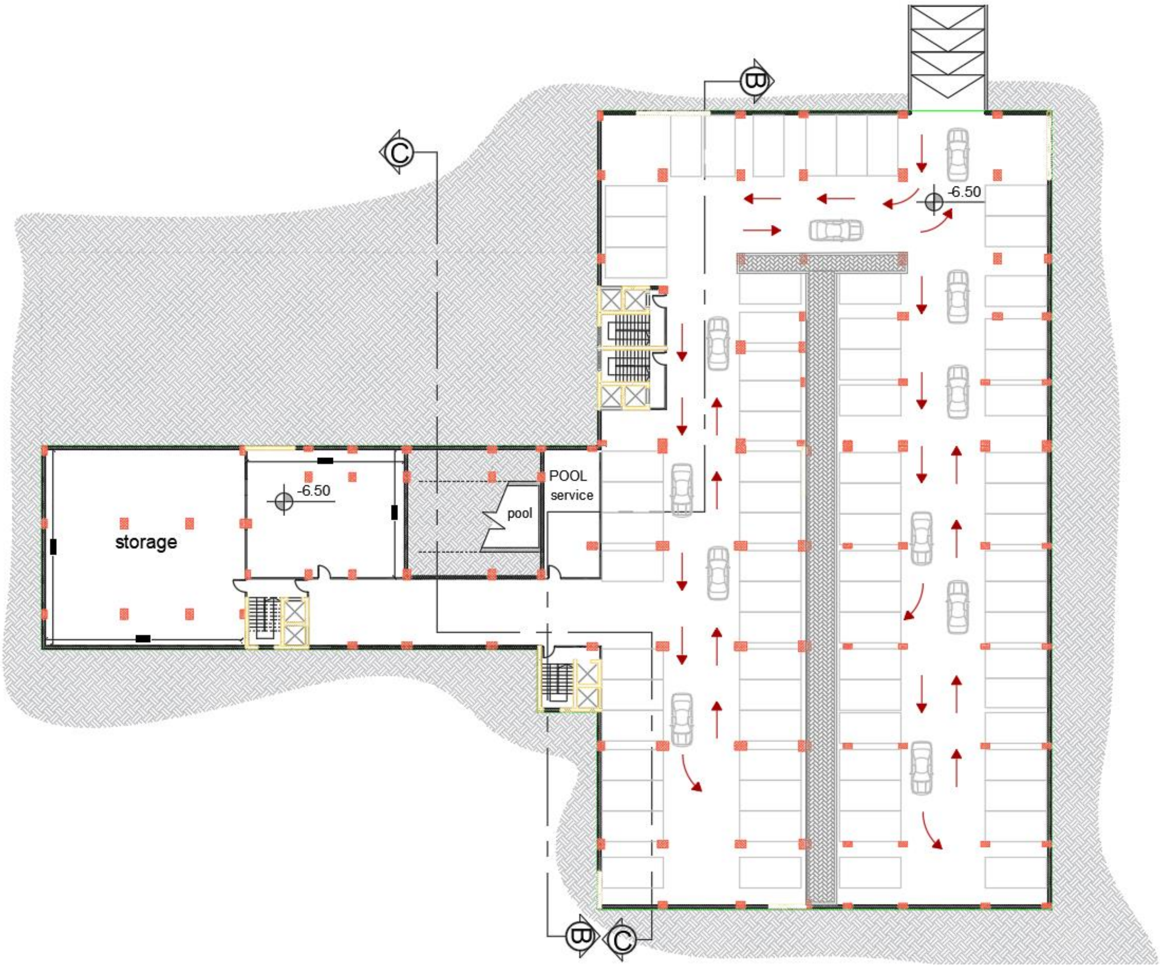


Figure 2-3: Parking Floor Plan

2.4.2 Basement Floor:

(Level – 3.50 m) with an area of 2490 m2.

The basement floor is a service floor containing a Breakfast kitchen, a gym, a laundry room, and a swimming pool.

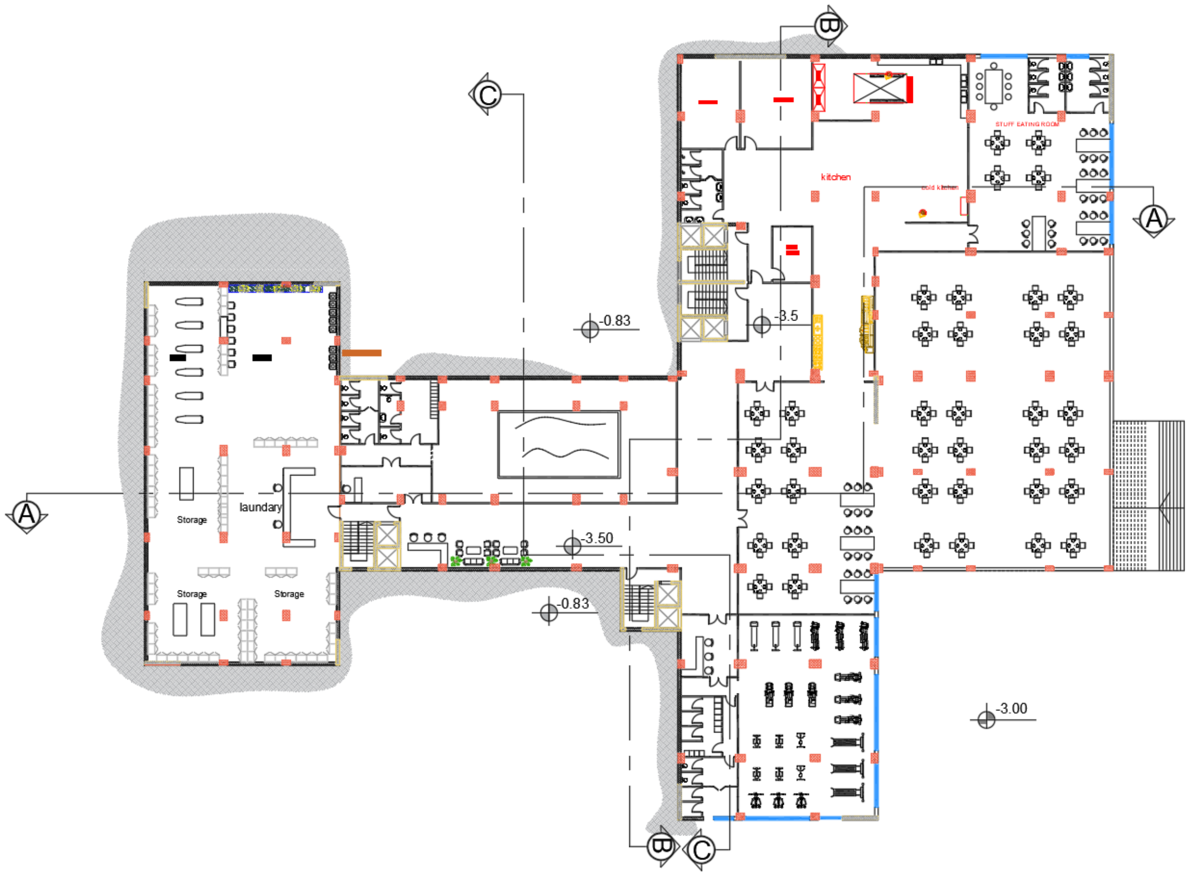


Figure 2-4: Basement Floor Plan

2.4.3 Ground Floor:

(Level +- 0.00 m) with an area of 2490 m2.

The ground floor, contains a reception, restaurant, and administration.

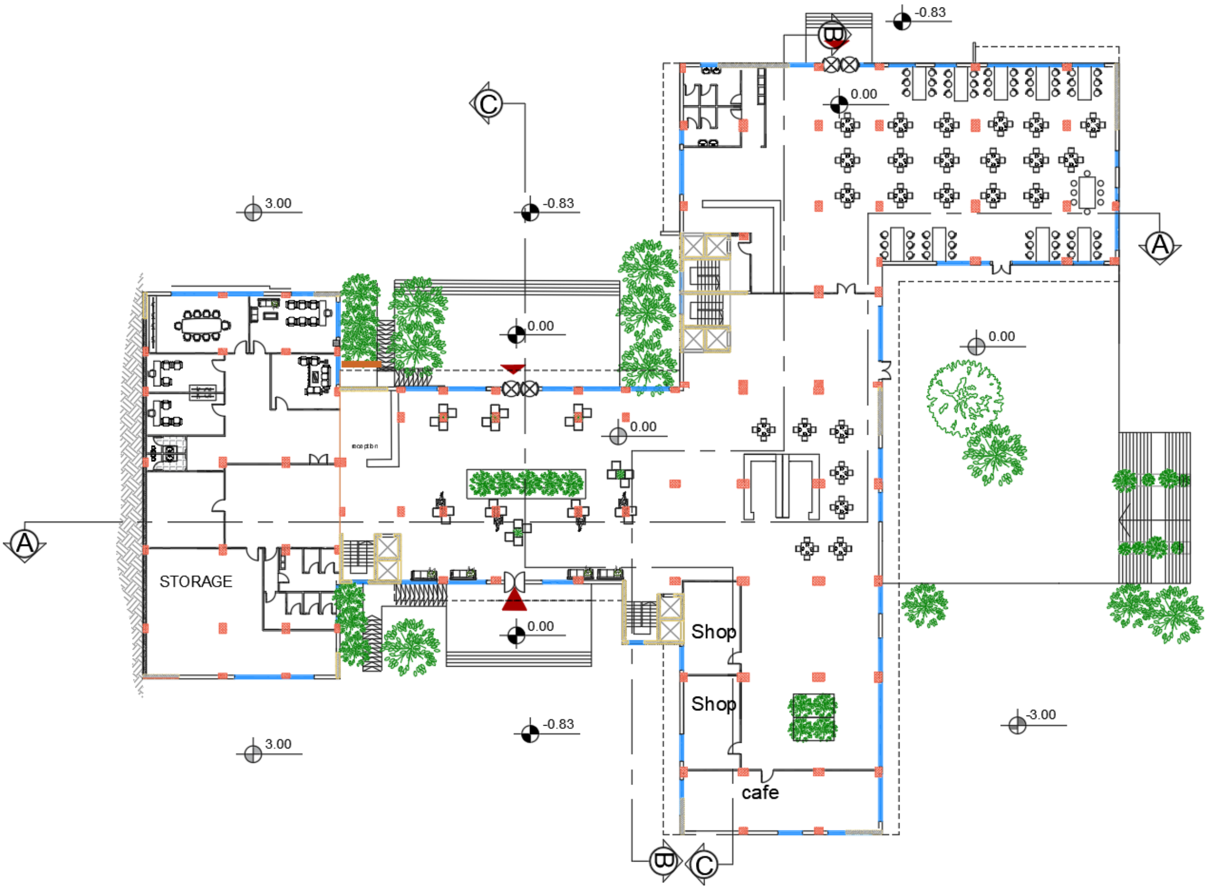


Figure 2-5:Ground Floor Plan

2.4.4 First & Second floor:

First floor: (Level + 7.40 m) with an area of 2695 m2.

Second floor: (Level + 10.70 m) with an area of 2695 m2.

The floors consists of hotel rooms, Multi use room and convention room.

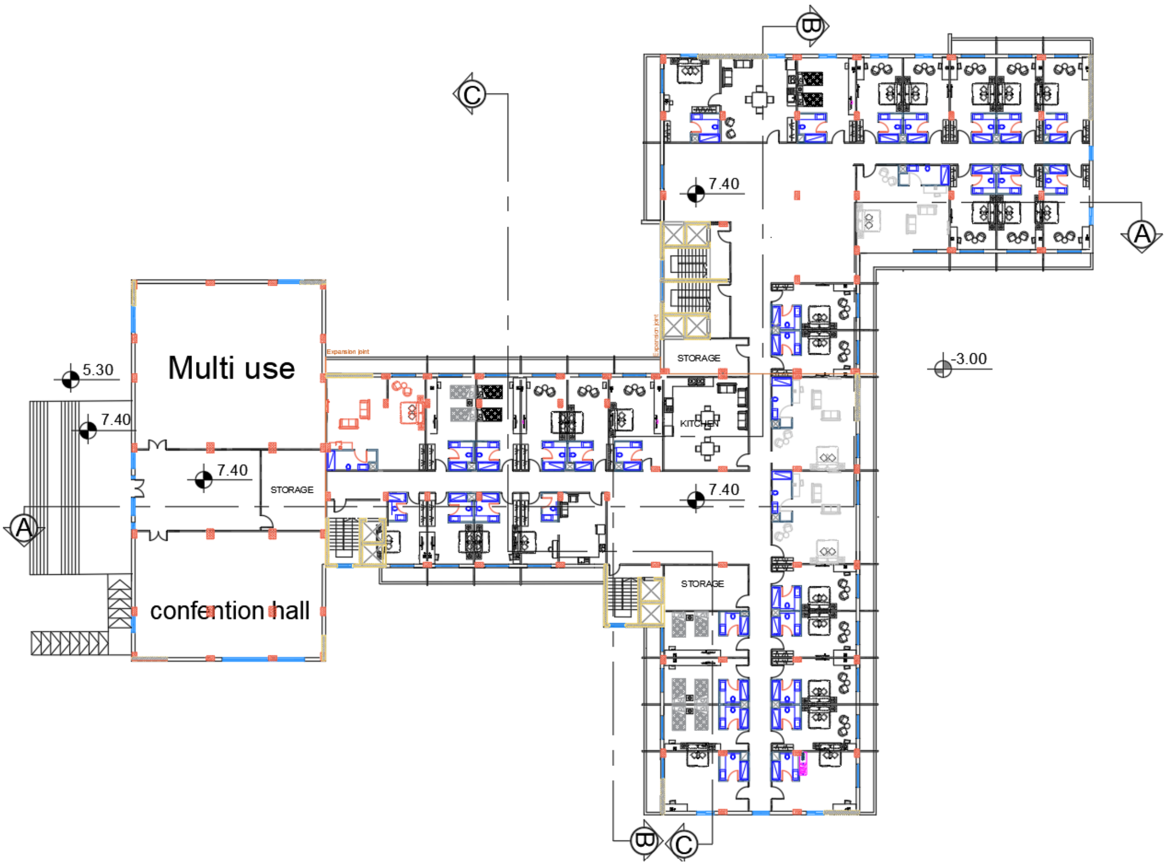


Figure 2-6: First & Second Floor Plan

2.4.5 Third & Forth floor:

Third floor: (Level + 14.00 m) with an area of 2695 m2.

Forth floor: (Level + 17.30 m) with an area of 2695 m2.

The floors consists of hotel rooms.

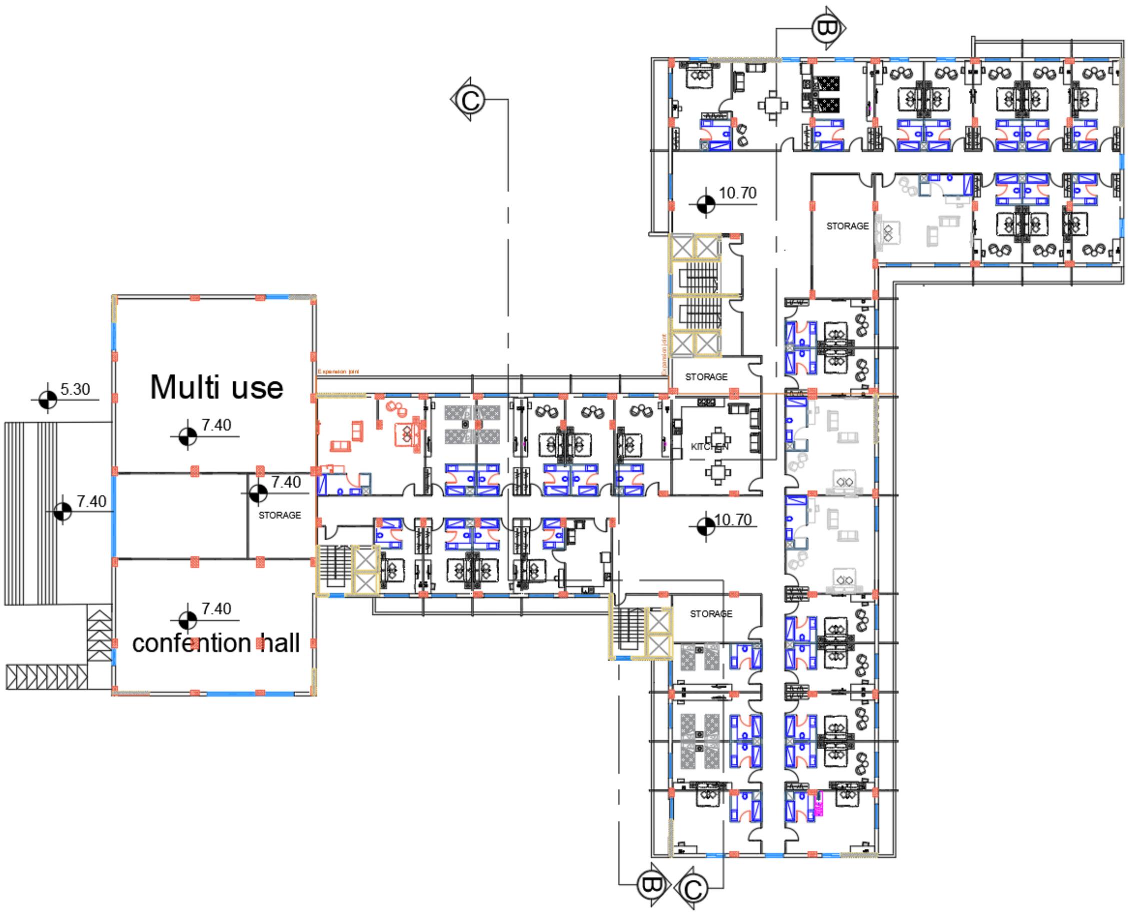


Figure 2-7: Third & Forth Floor Plan

2.5 ELEVATIONS DESCRIPTION

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

2.5.1 Northern Elevation:

This elevation is considered the main elevation of the hotel, and this elevation includes two entrances, with several types of stone, different shapes of windows, and different levels.

Figure 2-8: Northern Elevation

2.5.2 **Southern Elevation:**

The name of the hotel appears on the elevation with a type of stone. This elevation includes two entrances, with several types of stone, different shapes for windows, and different levels.

Figure 2-9 : Southern Elevation

2.5.3 **Eastern Elevation:**

Only one door appears in the elevation, and there is no change in slope, and there are several types of stone and windows.

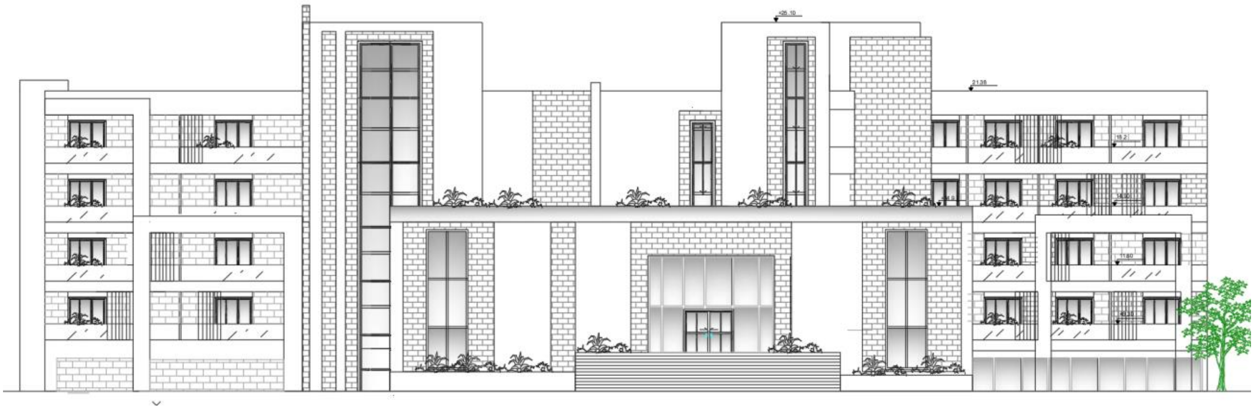


Figure 2-10: Eastern Elevation

2.5.4 Western Elevation:

On this elevation appears the word hotel with a type of stone. And the presence of one door on the ground level, with no change in slope, and the presence of several types of stone and windows.

Figure 2-11: Western Elevation

2.6 Sections

2.6.1 Section A-A

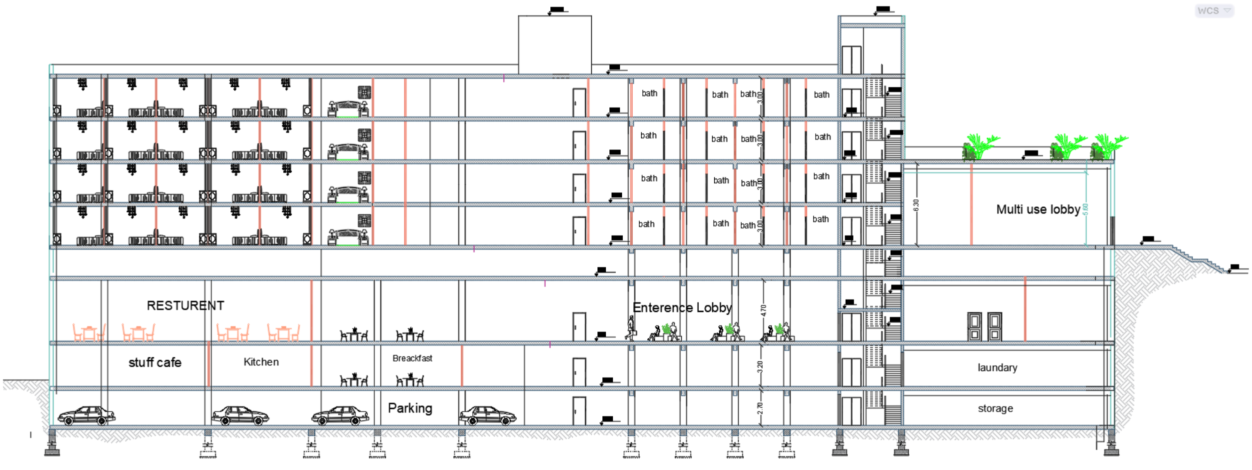


Figure 2-12: Section A-A

2.6.2 Section B-B

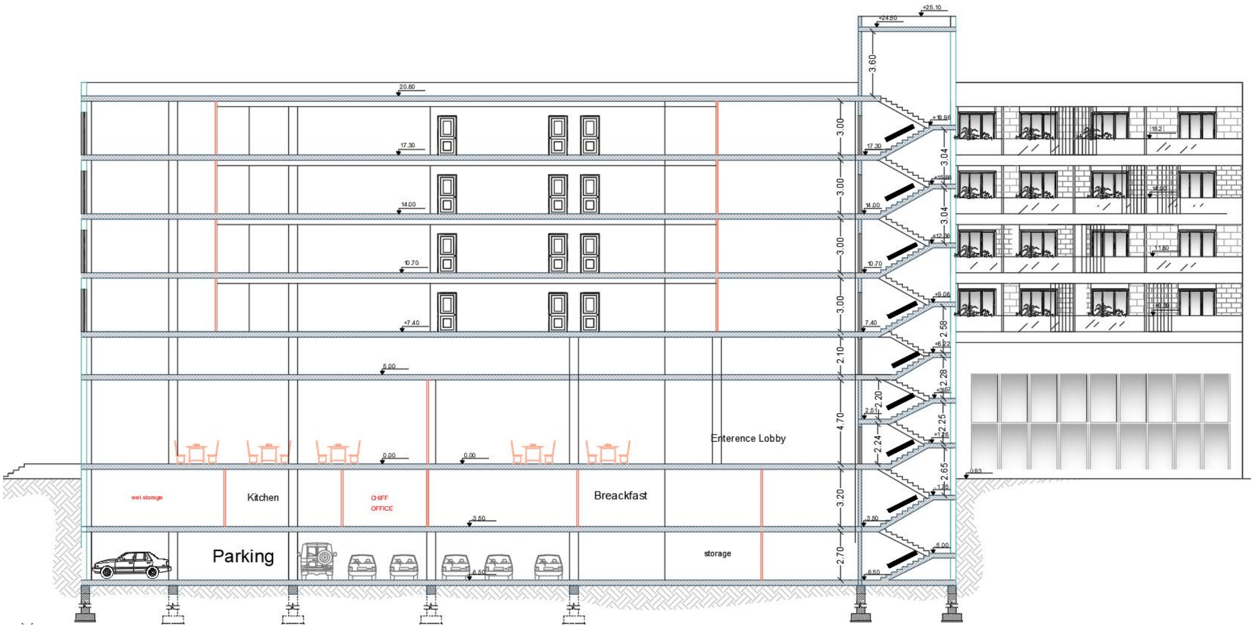


Figure 2-13 : Section B-B

2.6.3 Section C-C

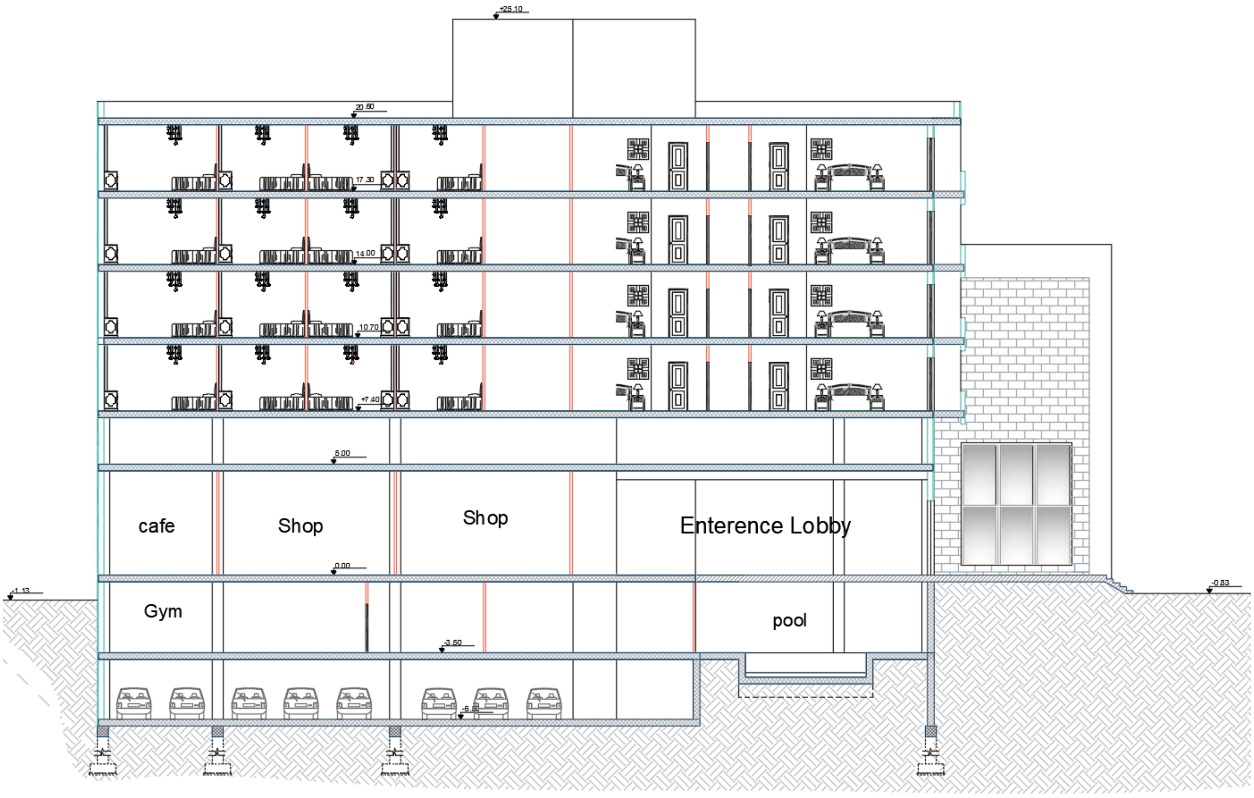


Figure 2-14: Section C-C

CHAPTER 3
" STRUCTURAL DESCRIPTION "

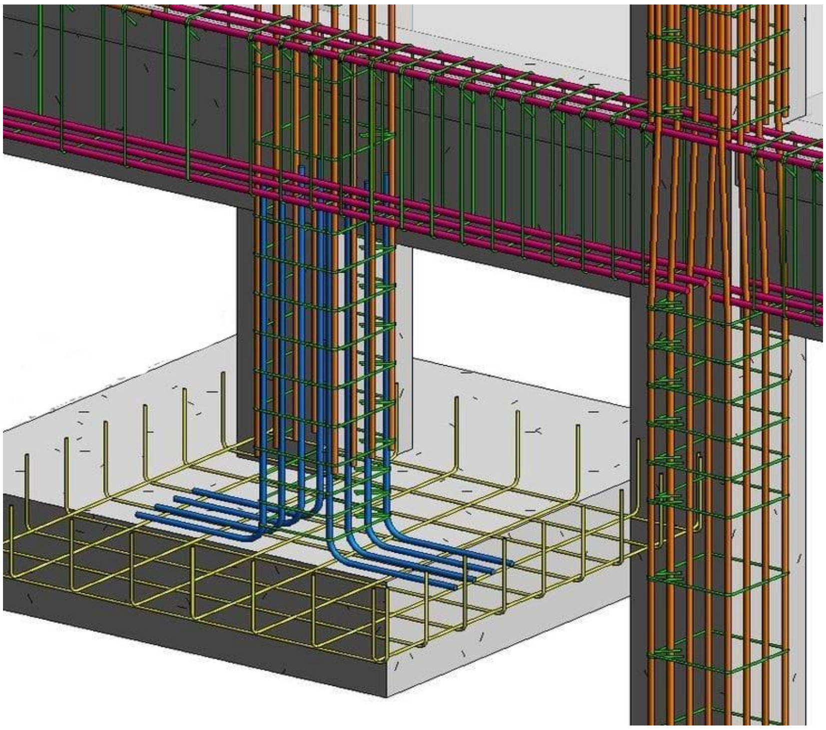
3.1 INTRODUCTION.

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.



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:

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

3.4.1 Dead Loads:-

They are the loads resulting from the self-weight of the main elements that make up the structure, on a permanent and fixed basis, such as tiles, cement mortar, and reinforced concrete, in terms of quantity and location, in addition to additional parts such as internal partitions of different types and any mechanical works or additions that are carried out permanently and permanently in the building, and can be calculated by determining the dimensions The structural element, and the densities of its constituent materials, and Table (1-3) shows the specific densities of the materials used in the project.

Table 3-1 : Specific density of the materials used.

Item No	Material	Specific Weight (KN/m3)
1	Tile	23
2	Mortar	22
3	Sand	17
4	Hollow Block	10
5	Reinforced Concrete	25
6	Plaster	22
7	Backfill	17

In addition to the dead load resulting from the breakers (Partition load) = 2.3 kN/m2

3.4.2 live loads:

They are the loads that change in terms of amount and location on an ongoing basis, such as people, furniture, devices, equipment, and execution loads such as wood and equipment. The value of these loads depends on the nature of the use of the facility.

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.

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

3.4.3 Environmental loads:

It includes the loads that result from the natural changes that pass through the structure, such as snow, winds, and heavy loads

Earthquakes and loads resulting from soil pressure, which vary in magnitude and direction and from one region to another, and can be considered as part of the live loads.

3.4.4 Earthquake loads:

Earthquakes result from horizontal and vertical vibrations, due to the relative movement of the rock layers of the earth, which results in shear forces that affect the facility. These loads must be considered when designing to ensure the building's resistance to earthquakes if they occur, and thus reduce potential damages as a result of an earthquake.

In this project, it will be resisted by the shear walls distributed in the building based on the structural calculations for it, which will be used for it, to avoid the effects resulting from earthquakes such as:

- The limits of the validity of the building for operation (Serviceability) in terms of avoiding any excessive subsidence (Deflection) and avoiding (Cracks) that negatively affect the required architectural appearance.
- The shape and aesthetic aspects of the establishment.

- So, in these project we design the building to resist earthquake by American concrete institute (ACI 2019) and American society of civil engineering (ASCE/SEI 7-16) based on Seismic Hazard Map For Building Codes in Palestine.

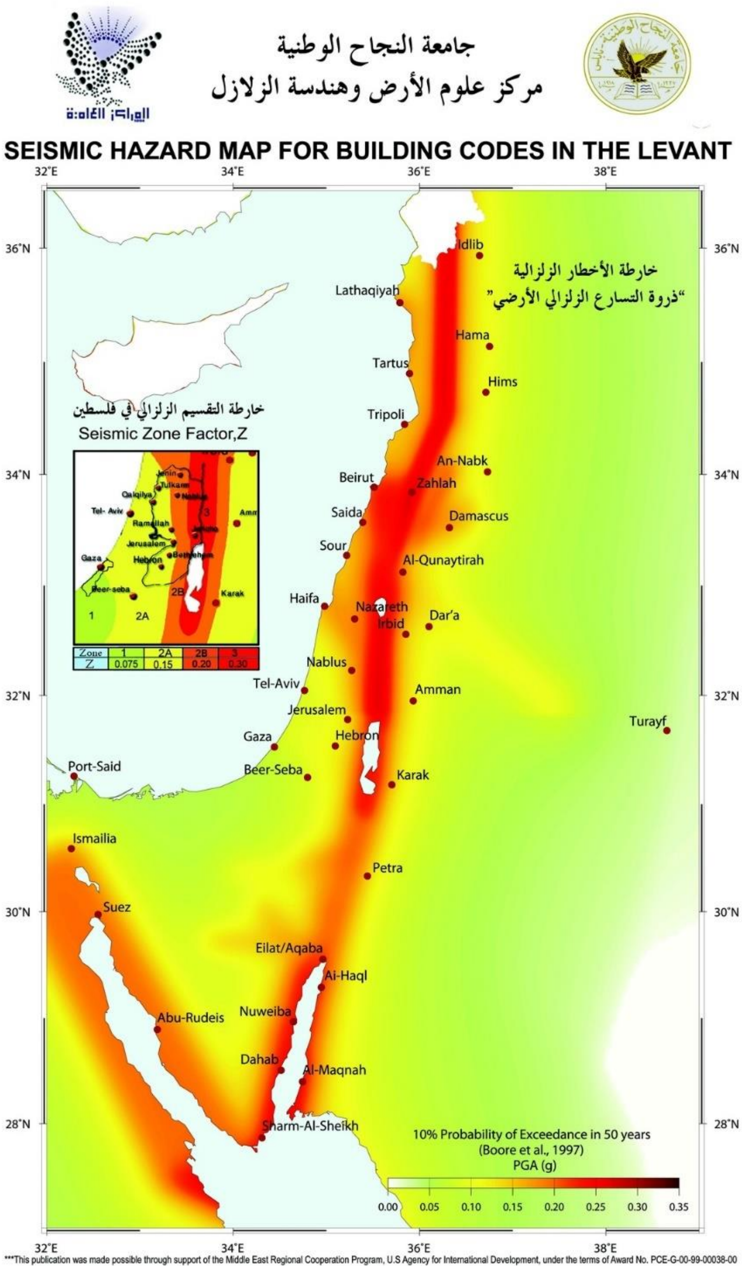


Figure 3-1: Seismic Hazard Map For Building Codes in Palestine.

3.5 Practical Tests:

The construction study of any building precedes the geotechnical studies of the site, and it means all the work related to the exploration of the site and the study of soil, rocks and groundwater, and the analysis of information and its translation to predict the way the soil behaves when building on it, and what the structural engineer is most interested in is obtaining the necessary soil bearing strength To design the foundations of the building, and from this step, the type of foundation that will be used for the building can be approved.

The bearing capacity of the soil in the project implementation area has reached 450 KN/m^2.

3.6 Structural Elements:

Buildings usually consist of a group of structural elements that intersect with each other to withstand the loads on the building, and they include: Slabs, Beams, columns, stairs, and foundations. Figure (2-3) shows an illustration of some structural elements of the building.

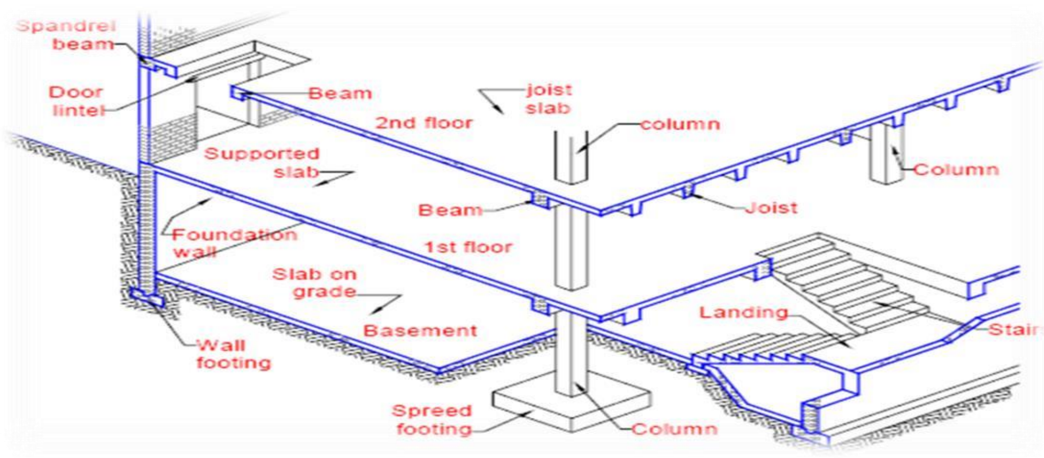


Figure 3-2 : Illustration of some structural elements of the building.

3.6.1 Slabs:

They are the structural elements that can transfer vertical forces due to the loads affecting them to the load-bearing structural elements in the building such as bridges, columns, walls, steps and foundations, without subjecting them to deformations.

Given the presence of many different activities in the building and considering the architectural requirements, the following types of Slabs will be used in the project.

3.6.1.1 Ribbed Slabs:

which are divided into:

- One-way ribbed slab
- Two-way ribbed slabs.

Only one way has used in the design of the building in the project.

One-way corrugated tiles are used to cover spaces whose dimensions are small.

The two-way polygonal slab is used in the case of relatively large areas.

In the structural design of this project, one-way rib slab and one-way solid slabs were used.

3.6.1.1.1 One-way ribbed slabs:

It is one of the most famous methods used in designing slabs in these countries, and it consists of a row of bricks followed by nerves, and the reinforcement is in one direction as shown in Figure (3-3). It is characterized by its light weight and effectiveness, and it is the most widely used in Palestine and in our project as well.

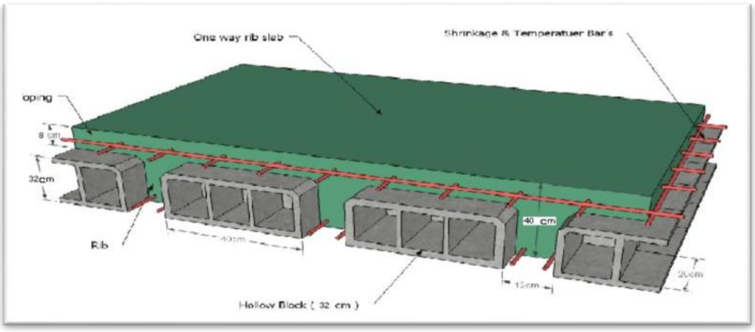


Figure 3-3 : One-way ribbed slabs.

3.6.1.1.2 Two-way ribbed slabs:

It is similar to the previous one in terms of components, but differs in terms of the reinforcement being in two directions, and the load is distributed in all directions, and two bricks and a beam are taken into account when calculating their weight in both directions, as shown in Figure.

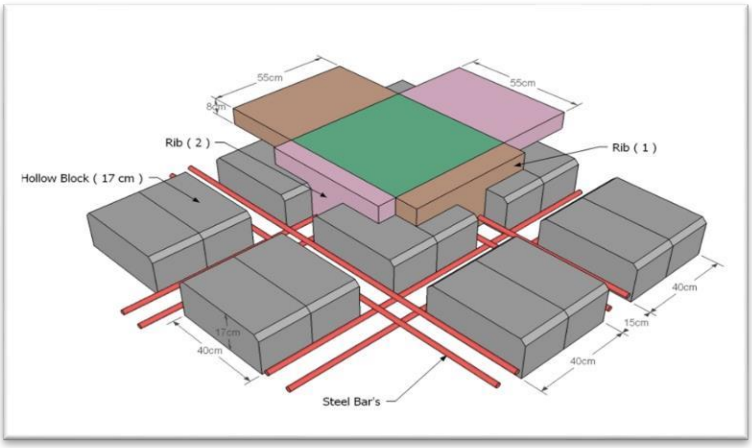


Figure 3-4 : Two-way ribbed slab

3.6.1.2 Solid slabs:

are divided into:

- One way solid slab .
- Two way solid slab.

One way and two way solid slab were used in this project.

3.6.1.2.1 One way solid slabs:

They are used in areas that are frequently subjected to dynamic loads, in order to avoid vibration due to the low thickness. They are usually used in stairs slabs, as in Figure.

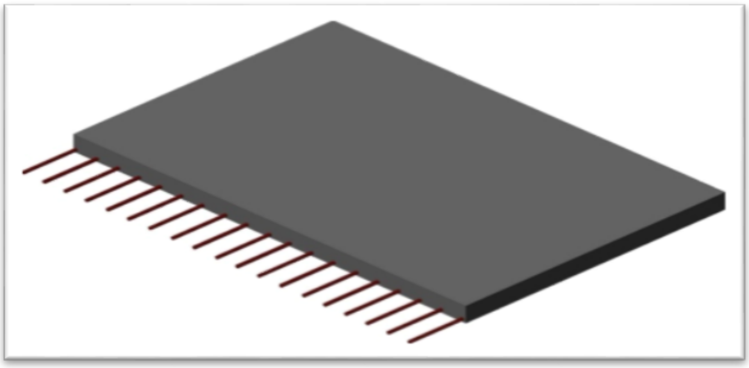


Figure 3-5 : One-way solid slabs.

3.6.1.2.2 Two way solid slabs:

It is used if the effective loads and the distances between the bridges are large, and then resort to the design of this type of panels, because this can resist the loads more, as the main reinforcement is distributed in two directions (as shown in the figure)

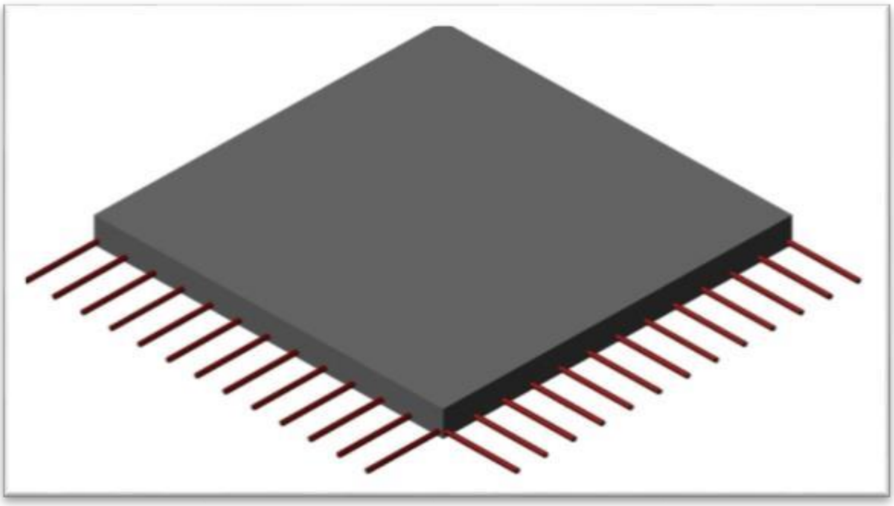


Figure 3-6 : Two-way solid slabs.

In this project, atype of slabs was used one way ribbed slabs and one way solid slabs.

3.6.2 **Beams:-**

They are basic structural elements in the building that transfer the loads on the ribs to the columns, as they are divided into:

1- Hidden beams, whose height is equal to the height of the slab.

2- Dropped beams, which are higher than the height of the slab, and the extra part of the beam is highlighted in one of the lower or upper directions.

The reinforcement shall be with horizontal steel bars to resist the moment on the beam, and with stirrups to resist shear forces. The figure below shows the types of beams that were used in the project.

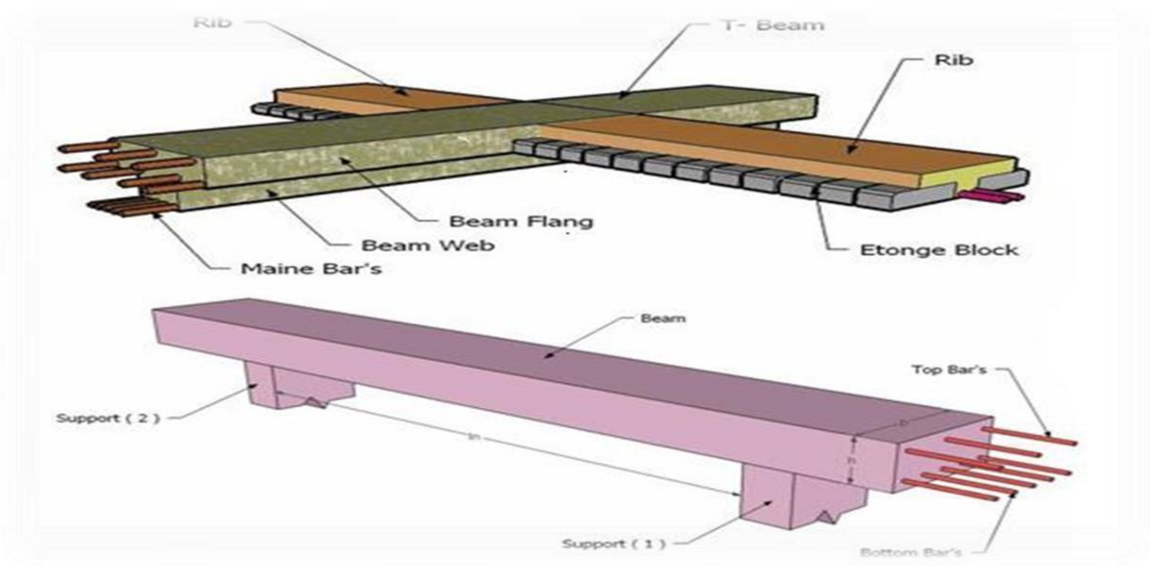


Figure 3-7 : Types of beams that were used in the project.

3.6.3 Columns:

They are basic and major structural elements in the structure, where the loads are transferred from the slab to the beams, and the beams transfer them in turn to the columns, then to the foundations of the building, so they are an essential intermediate element, and they must be carefully designed to be able to transfer and distribute the loads located on them and the columns are of two types in terms of dealing with them In structural design:-

1- Short columns.

2- Long columns.

As for the architectural form or the engineering section, the project contains three types of columns, which are square, rectangular and circular.

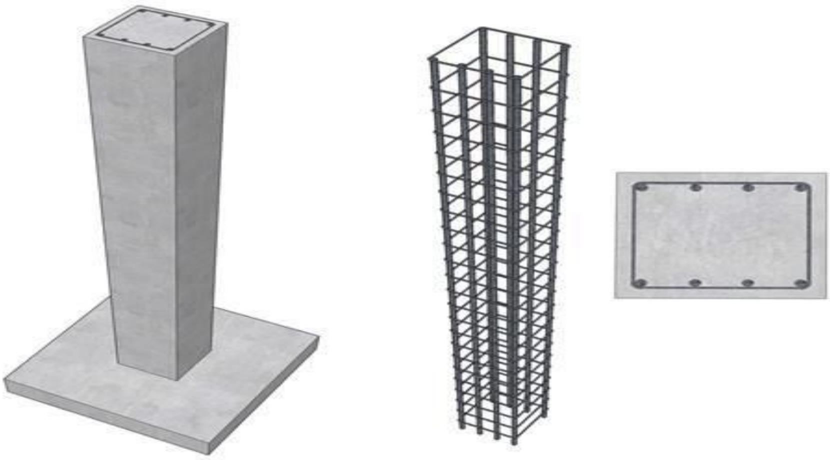


Figure 3-8 : Some Types of columns that were used in the project.

3.6.4 expansion joints:

In building blocks with large horizontal dimensions or with special shapes and conditions, thermal expansion joints or subsidence joints are implemented. The joints may be for both purposes. When analyzing the facilities to study them as resistant to earthquake actions, these joints are called seismic joints. These joints have some requirements and recommendations for them, and they should also be used Thermal expansion joints 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 dimensions of the building block are as follows:

- 40m in areas with high humidity.
- (36m) in areas with normal humidity.
- (32m) in areas with medium humidity.
- (28m) in dry areas.

The width of the separator shall not be less than 3 meters.

In this project, a vertical expansion joint was used.

3.6.5 Foundations:

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

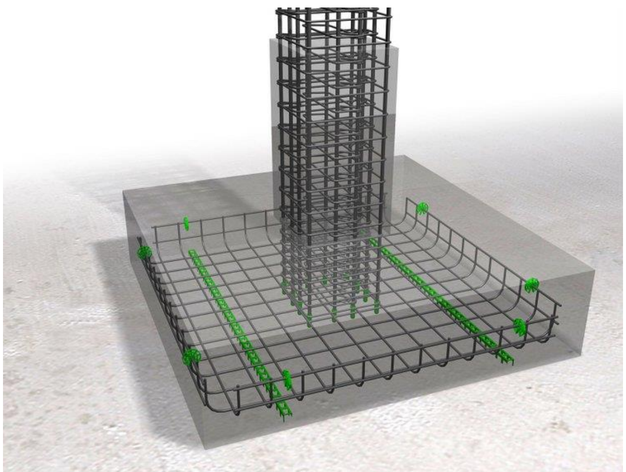


Figure 3-9: isolated Foundation

3.6.6 Shear Walls:

Shear walls are the walls that resist horizontal forces such as wind forces and earthquakes, and be in the walls of the stairwell and the walls of the elevators

In our project we used:

- Continues shear wall (staircase)

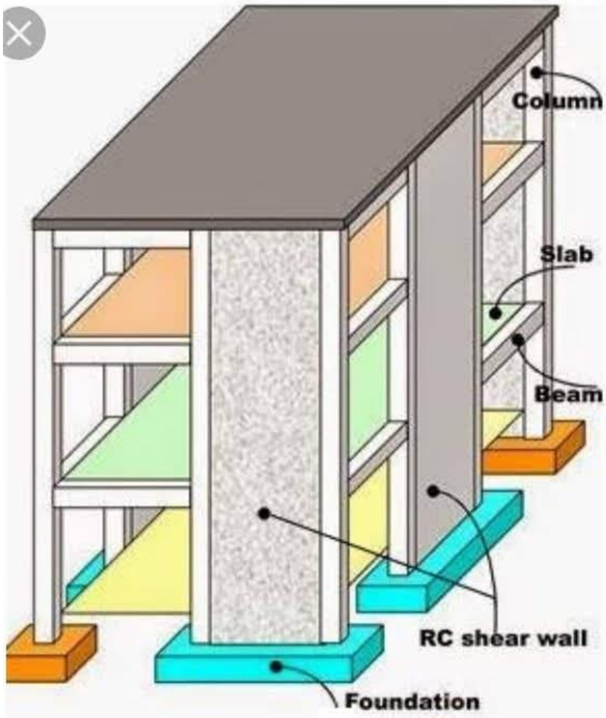


Figure 3-10: Shear Wall

3.6.7 **Stairs:**

The staircase is an architectural element in the building to move between two levels or move between floors.

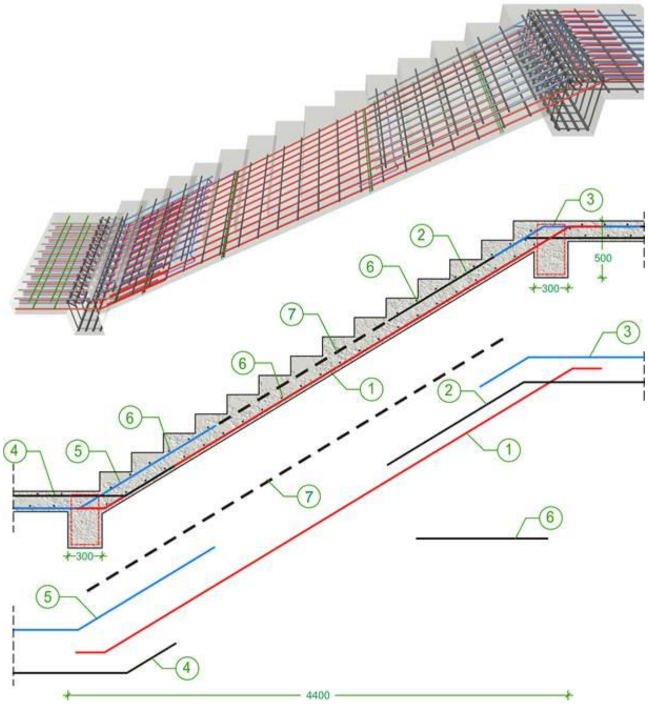


Figure 3-11 : Stairs

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 SECOND FLOOR ONE-WAY RIBBED SLAB.

4.8 DESIGN OF BEAM.

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, all of design calculation for all structural members would be made upon the structural system which was chosen in the previous chapter.

So, in this project, there are many types of slabs such that “one-way ribbed slab”, They would be analyzed and designed by using finite element method of design, with aid of a computer program called "Atir Beam-D Software” to find the internal forces, deflections and moments for ribbed slabs, and then handle calculation would be made to find the required steel for all members.

4.2 Design method and requirements:

The design strength provided by a member, its connections to other members, and its cross sections in terms of flexure, and load, shear, and torsion is taken as the nominal strength calculated in accordance with the requirements and assumptions of ACI-318-14 code.

The design strength provided by a member is calculated in accordance with the requirements and assumptions of ACI code (318_14).

Strength design method:

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

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

The strength design method is expressed by the following,

Strength provided ≥ Strength required to carry factored loads.

Material:

Reinforced Concrete: B300, fc′ = 24 N/mm2 (MPa)

Reinforcement Rebars: f_y = 420 N/mm2(MPa)

- Strength reduction factors (Ø):

According to ACI a reduction factor for structural elements must be included in the calculation of concrete sections, these factors are less than 1.0 for safety purposes, 0.9 for tension-controlled sections, 0.75 (Spiral) or 0.65 (Stirrups) for compression-controlled sections, 0.75 in shear calculation and 0.6 for plain concrete sections. The strength factor (Ø) changes with net tensile strain of the cross section as illustrated in the following figure:

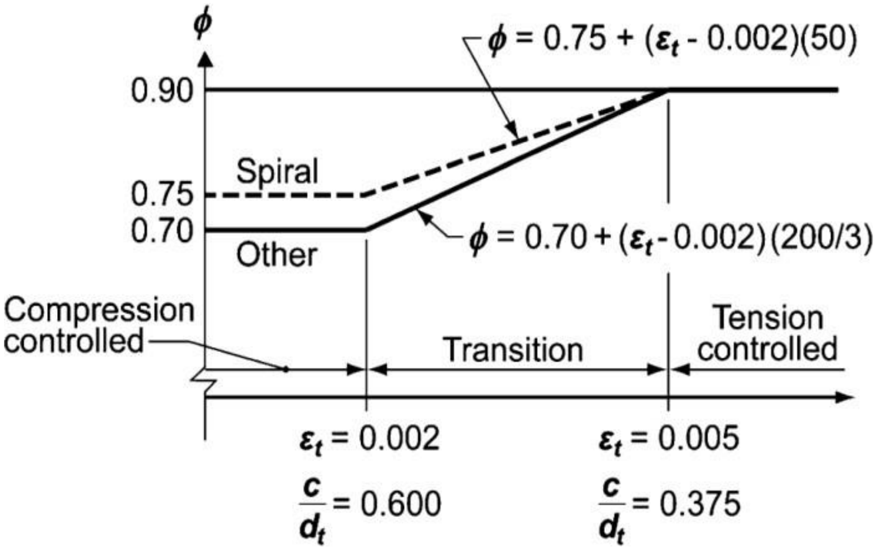


Figure 4-1: Variation of Ø factor with net tensile strain (ACI 318)

4.3 Factored loads:

The factored loads used in the structural analysis and design according to ACI-318-11(9.2) eq.

, is determined as follows:

$\mathbf{Wu} = \mathbf{1.2DL} + \mathbf{1.6LL}$

Where:

Wu: Ultimate Load (kN)

DL: Dead Load (kN)

LL: Live Load (kN)

4.4 Determination of minimum thickness of structural members:

Minimum thickness of non-prestressed beams or one-way ribbed slabs unless deflections are calculated. (ACI 318M-11)

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

Table 4-1 : Determination of minimum thickness of structural member.

For rib 007 Parking Slab:

$\frac{L}{18.5} = \frac{6.4}{18.5} = 34.5\ cm$ …For One end continuous. (for rib)

Select Slab thickness h = 32 cm but we run it on safe and Atir and the deflection was ok.

4.5 Design of one-way ribbed slab (007):

One-way ribbed slab Design procedure is explained in the following steps:

4.5.1 Design of Topping:

Topping in One-way ribbed slab can be considered as a strip of 1-meter width and span of hollow block length with both ends fixed in the ribs.

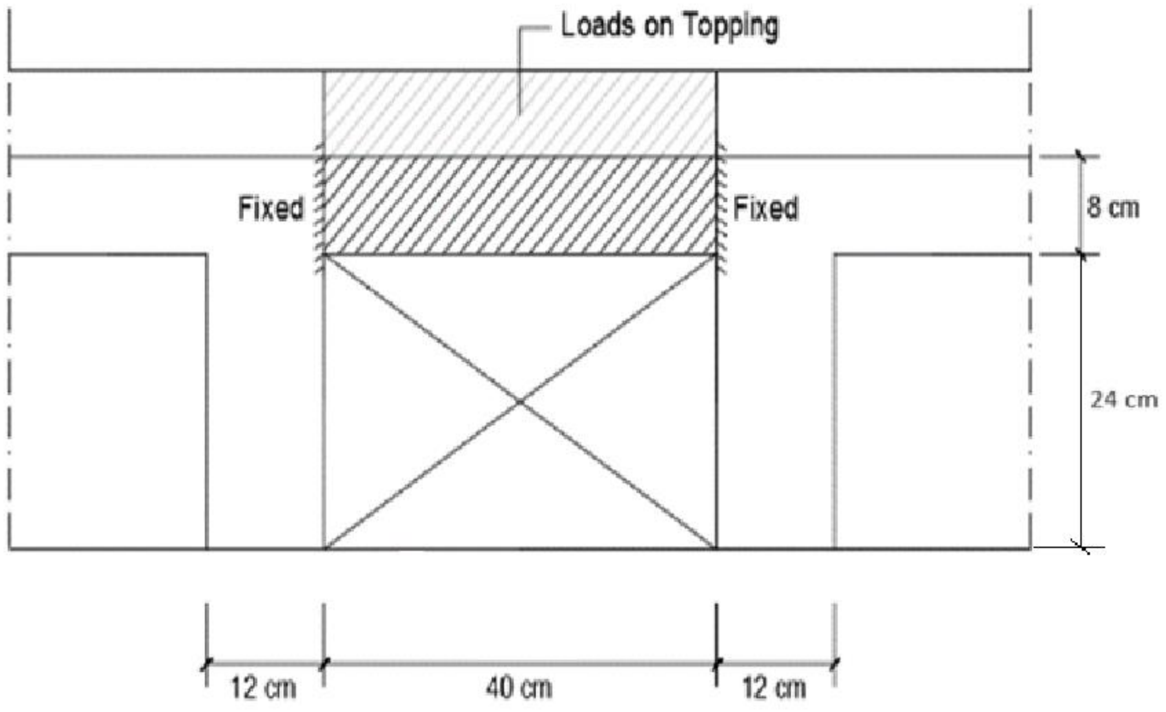


Figure 4-2 : System of Topping

4.5.2 Calculation of Loads on Topping

Dead loads that act on Topping can be calculated as shown in the following table:

→ Dead Load For 1m strip:

No.	Material	Quality Density KN/m3	DL (KN/m)	
1	Topping	25	**0.08×25 ×1= 2**	
2	Coarse Sand	17	**0.07×17×1 = 1.19**	
3	Mortar	22	**0.03×22×1 =0.66**	
4	Tile	23	**0.03×23×1 =0.69**	
5	interior partition	**2.3*1=2.3 KN/m**		
		∑ =	**6.84**	**KN/m**

Table 4-2 : Dead Load Calculation For Topping.

Live Load For 1m strip = 4 × 1 = 4 kN/m

Factored load (W_u) = 1.2 × DL + 1.6 × LL

= 1.2×6.84 + 1.6×4 = 14.6 kN/m. (Total Factored Load).

$$M_u = \frac{W_u * l^2}{12} = \frac{14.6 * 0.4^2}{12} = 0.195\ kN.m\ .$$

4.6 DESIGN OF TOPPING

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

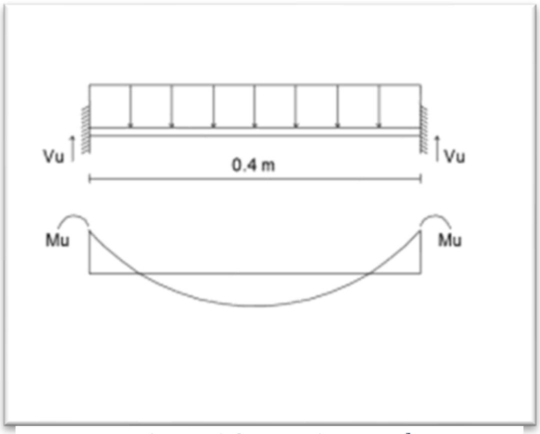


Figure 4-3 :Topping Load

- ✓ 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)**

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

$\emptyset M_n = 0.55\times0.42\times1\times\sqrt{24}\times1066666.67\times10^{-6}$ =2.19 KN.m

$M_u = \frac{W_u L^2}{12} = \frac{14.6*0.4^2}{12} = 0.194 KN.m$ (negative moment)

$M_u = \frac{W_u L^2}{24} = \frac{14.6*0.4^2}{24} = 0.0973\ KN.m$ (positive moment)

$\emptyset M_n = 2.19\ KN.m > M_u = 0.194\ KN.m$

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

4.7 DESIGN OF ONE-WAY RIBBED SLAB (Rib 007) From Project

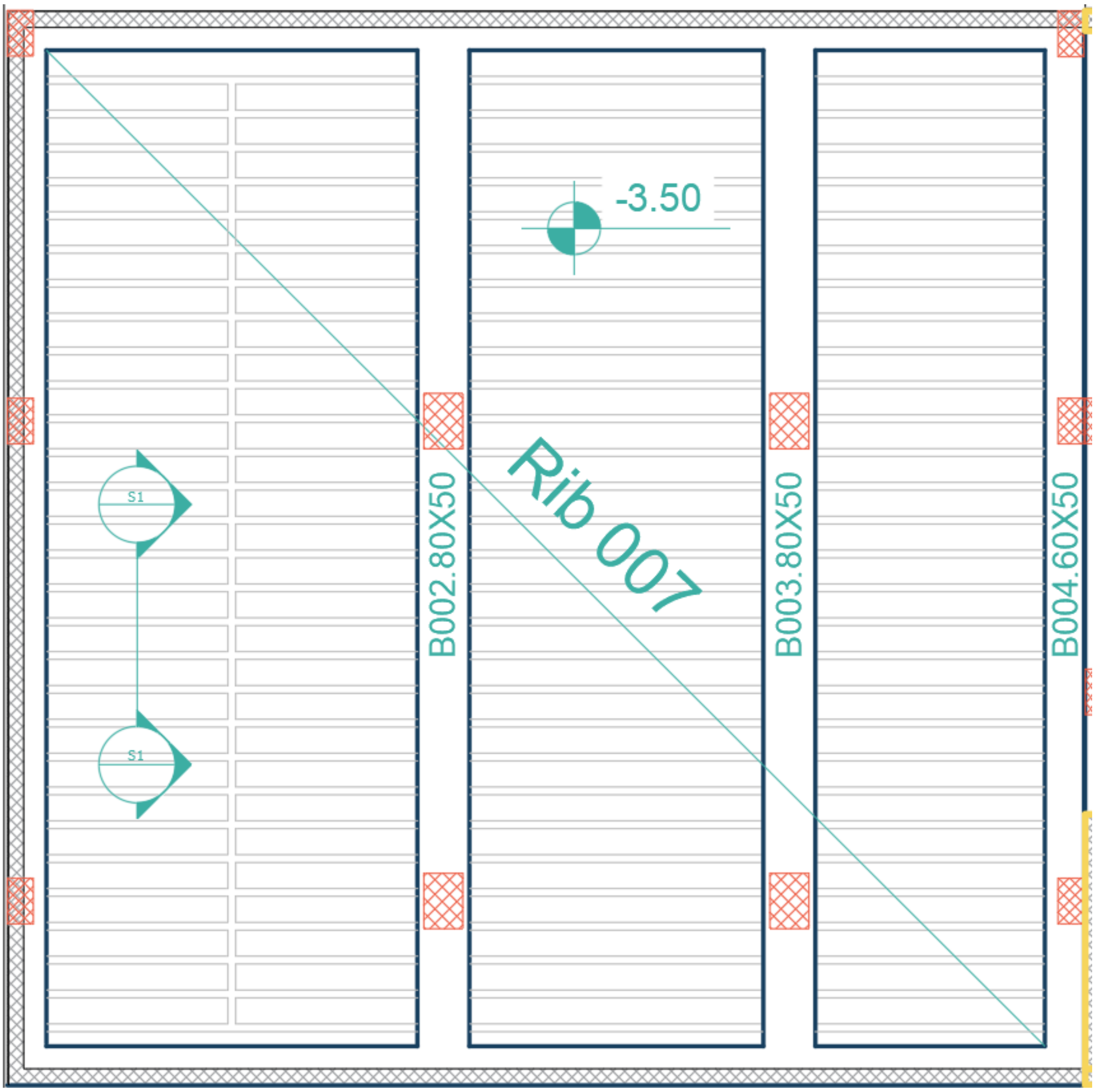


Figure 4-4 : Rib 007 From Project

Loads:

No.	Material	Quality Density KN/m3	DL (KN/m)	
1	Topping	25	**0.08×25 ×0.52= 1.04**	
2	Tile	23	**0.03×23×0.52 =0.359**	
3	Mortar	22	**0.03×22×0.52 =0.343**	
4	CR Rib	25	**0.24×25 ×0.12= 0.72**	
5	Coarse Sand	17	**0.07×17×0.52 = 0.619**	
6	Hollow Block	22	**0.24×10 ×0.4= 0.96**	
7	Plaster	22	**0.03×22×0.52 =0.343**	
8	interior partion		**2.3*0.52=1.196**	
			∑ =	**5.61** **KN/Rib**

Table 4-3: Dead Load Calculation for Rib 007

Live Load For 1 Ribbed = $4 \times 0.52 = 2.08$ kN/Rib

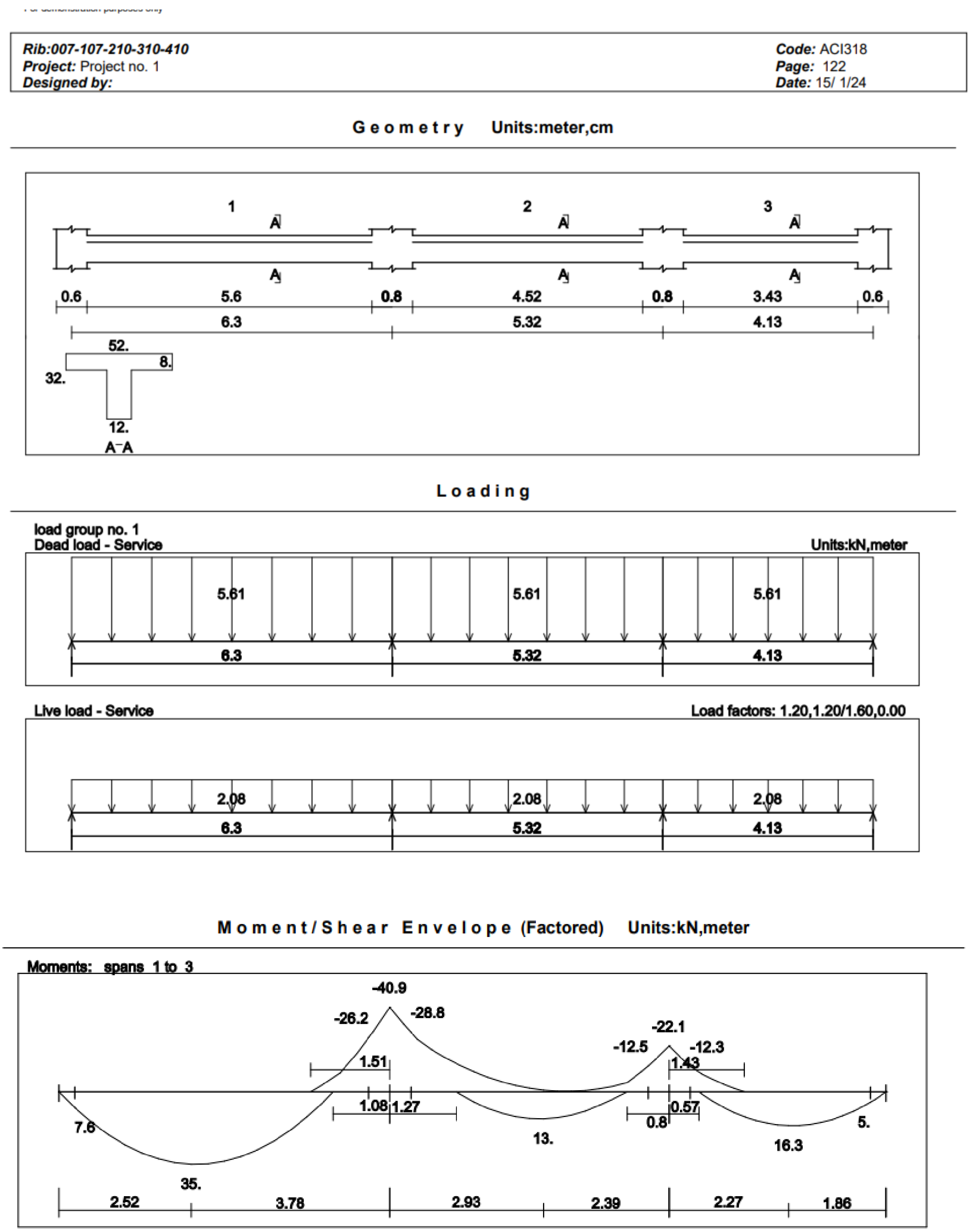


Figure 4-5 : Load & Moment Envelope deagram for Rib 007

✓ Material:

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel Fy = 420 N/mm^2

✓ Section:

b =12cm b_f= 52 cm

h =32cm T_f = 8 cm

4.7.1 Design for Flexure

✓ Design for positive moment (M_u =35 KN.m)

Assume bar diameter **Ø16** for main reinforcement.

Assume bar diameter **Ø10** for stirrups.

D = $320 - 20 - 10 - \frac{16}{2}$ = 282 mm

Check if $a > h_f$:

$\overline{Mn_f} = 0.85 f_{\acute{c}}\, b\, h_f (d - \frac{h_f}{2}) = 0.85 \times 24 \times 520 \times 80 \times (282 - \frac{80}{2}) \times 10^{-6}$ = 205.37 KN.m

$\overline{Mn_f} \gg M_u$ …. $\boldsymbol{a < h_f}$

$\overline{Mn_f} = 205.37\ \text{KN.m} \gg M_u$ =35 KN.m

The section is as rectangular section.

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{35\times10^6}{0.9\times520\times282^2}$ = 0.94 MPa

m = $\frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85\times24}$ = 20.58

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}}) = \frac{1}{20.58}(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.94}{420}}) = 0.00229$

$A_s = \rho \times b \times d = 0.00229 \times 520 \times 282 = 336.13\ mm^2$

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

$A_{s_{min}} = 0.25 \times \frac{\sqrt{24}}{420} \times 120 \times 282 \ \geq \ \frac{1.4}{420} \times 120 \times 282$

$A_{s_{min}} = 98.67\ mm^2 \leq 112.8\ mm^2$ **...... Control**

$A_s = 336.13\ mm^2 > A_{s_{min}} = 112.8\ mm^2$

Use **2∅16**

$\boldsymbol{A_{s_{provid}} = 402.124\ mm^2 > A_{s_{req}} = 336.13\ mm^2}$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{402.124 \times 420}{0.85 \times 24 \times 520} = 15.9\ mm$

$c = \frac{a}{0.85} = \frac{15.9}{0.85} = 18.73\ mm$

$\varepsilon_s = 0.003\left(\frac{d-c}{d}\right) = 0.003\ (\frac{282-18.73}{18.735}) = 0.04 > 0.005$ **OK.**

- ✓ Design for positive moment (M_u =13 KN.m)

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{13 \times 10^6}{0.9 \times 520 \times 282^2} = 0.349\ MPa$

$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.58$

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}}) = \frac{1}{20.58}(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.349}{420}}) = 0.000838$

$A_s = \rho \times b \times d = 0.000838 \times 520 \times 282 = 122.9\ mm^2$

$A_s = 122.9\ mm^2 > A_{s_{min}} = 112.8\ mm^2$

Use $\mathbf{2\emptyset 10}$

$\boldsymbol{A_{s_{provid}} = 157\ \ mm^2 > A_{s_{req}} = 122.9\ mm^2}$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{157 \times 420}{0.85 \times 24 \times 520} = 6.216$ mm

$c = \frac{a}{0.85} = \frac{6.216}{0.85} = 7.3$ mm

$\varepsilon_s = 0.003\left(\frac{d-c}{d}\right) = 0.003\ (\frac{282-7.3}{7.3}) = 0.11 > 0.005$ **OK.**

- ✓ Design for positive moment (M_u =16.3 KN.m)

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{16.3 \times 10^6}{0.9 \times 520 \times 282^2} = 0.4379$ MPa

$m = \frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.58$

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}}) = \frac{1}{20.58}(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.4379}{420}}) = 0.001054$

$A_s = \rho \times b \times d = 0.001054 \times 520 \times 282 = 154.5\ mm^2$

$A_s = 154.5\ mm^2 > A_{s_{min}} = 112.8\ mm^2$

Use $\mathbf{2\emptyset 10}$

$\boldsymbol{A_{s_{provid}} = 157\ \ mm^2 > A_{s_{req}} = 145.5\ mm^2}$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{157 \times 420}{0.85 \times 24 \times 520}$ = 6.216 mm

$c = \frac{a}{0.85} = \frac{6.216}{0.85}$ = 7.3 mm

$\varepsilon_s = 0.003 \left(\frac{d-c}{d}\right)$ = 0.003 ($\frac{282-7.3}{7.3}$) = 0.11 > 0.005 **OK.**

- ✓ Design for negative moment (M_u= -28.8 KN.m)

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{28.8 \times 10^6}{0.9 \times 120 \times 282^2}$ = 3.35 MPa

m = $\frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24}$ = 20.58

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}}) = \frac{1}{20.58}(1 - \sqrt{1 - \frac{2 \times 20.58 \times 3.35}{420}})$ = 0.008768

$A_s = \rho \times b \times d$ = 0.008768× 120 × 282 = 229.7 mm^2

$A_s = 229.7\ mm^2 > A_{s_{min}} = 112.8\ mm^2$

<u>Use **2∅14**</u>

$$\boldsymbol{A_{s_{provid}} = 307.87\ mm^2 > A_{s_{req}} = 145.5\ mm^2}$$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{307.87 \times 420}{0.85 \times 24 \times 120}$ = 52.82 mm

$c = \frac{a}{0.85} = \frac{52.82}{0.85}$ = 62.14 mm

$\varepsilon_s = 0.003 \left(\frac{d-c}{d}\right)$ = 0.003 ($\frac{282-62.14}{62.14}$) = 0.01 > 0.005 **OK.**

- ✓ Design for negative moment (M_u= -12.5 KN.m)

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{12.5 \times 10^6}{0.9 \times 120 \times 282^2}$ = 1.455 MPa

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

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}}) = \frac{1}{20.58}(1 - \sqrt{1 - \frac{2 \times 20.58 \times 1.455}{420}})$ = 0.0035976

$A_s = \rho \times b \times d$ = 0.0035976× 120 × 282 = 121.742 mm^2

$A_s = 121.742\ mm^2 > A_{s_{min}} = 112.8\ mm^2$

Use **2∅10**

$\boldsymbol{A_{s_{provid}} = 157\ \ mm^2} > \boldsymbol{A_{s_{req}}} = 121.742\ \boldsymbol{mm^2}$

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

$a = \frac{A_s \times f_y}{0.85 \times f_c' \times b} = \frac{157 \times 420}{0.85 \times 24 \times 120}$ = 26.936 mm

$c = \frac{a}{0.85} = \frac{26.936}{0.85}$ = 31.69 mm

$\varepsilon_s = 0.003\left(\frac{d-c}{d}\right) = 0.003\ (\frac{282-31.69}{31.69})$ = 0.02 > 0.005 **OK.**

4.7.2 Design For Shear

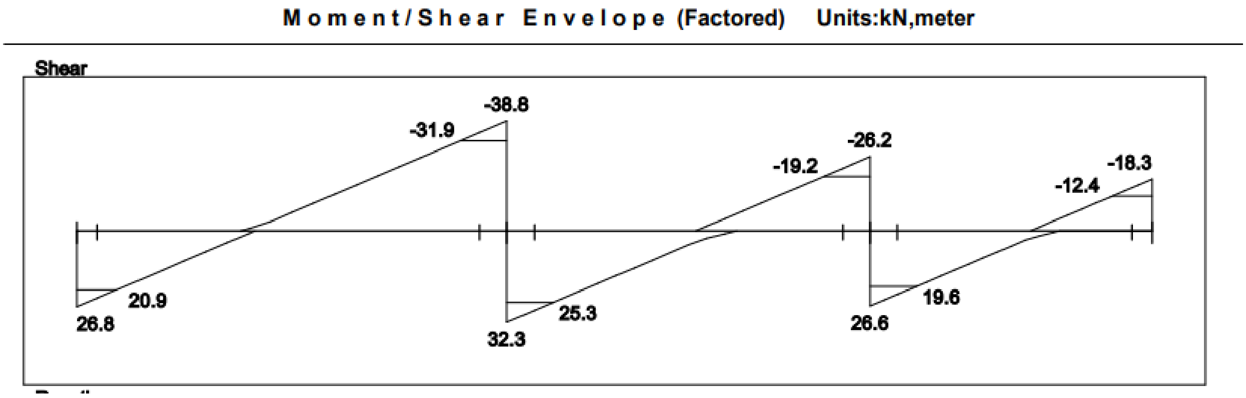


Figure 4-6:Shear Envelope diagram for Rib 007

✓ $(\boldsymbol{V_{u,d}} = \mathbf{31.9}\ \boldsymbol{KN})$

d = $320 - 20 - 10 - \frac{16}{2}$ = 282 mm

$\emptyset V_c = \emptyset\ \frac{1.1}{6} . \lambda . \sqrt{f_{\acute{c}}} . b_w . d$ = $0.75 . \frac{1.1}{6} . 1 . \sqrt{24} . 120 . 282. 10^{-3}$ = 22.79 KN

$\frac{1}{2} \emptyset V_c = \frac{1}{2} \times 22.79$ = 11.4KN

Check For Cases:

<u>Case1</u>: $V_u \leq \frac{\phi V_c}{2}$

31.9 > 11.4

∴ Case (1) is NOT satisfied.

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

11.4 < 31.9 < 22.79

∴ Case (2) is NOT satisfied.

<u>Case 3</u>: $\phi V_c < V_u \leq (\phi V_c + \phi Vs_{min})$

ϕ Vs_{min} $\geq$ $\frac{\phi}{16}\sqrt{f_c'}$ * b_w * d = $\frac{0.75}{16}\sqrt{24}$ * 120 *282* 10^{-3} =7.77 KN.

$\geq$ $\frac{\phi}{3}$ * b_w * d = $\frac{0.75}{3}$ * 120 * 282 * 10^{-3} = 8.46 KN …. **Control**.

∴ϕVs_{min} = 8.46 KN.

ϕV_c + ϕVs_{min} = 22.79 + 8.46 = 31.25 KN.

ϕV_c< V_u $\leq$ (ϕV_c + ϕVs_{min})

22.79 < 31.9 ≤ 31.25 ….

∴ Case (3) is NOT satisfied.

Case 4: (ϕV_c + ϕVs_{min})< V_u $\leq$ (V_c + $\phi Vs'$)

$\phi Vs'$ = $\frac{\phi}{3}\sqrt{f_c'}$ * b_w * d = $\frac{0.75}{3}\sqrt{24}$ * 120 *282* 10^{-3} =41.445 KN.

ϕV_c + $\phi Vs'$ = 22.79 + 41.445 = 64.23 KN.

31.25 < 31.9 ≤ 64.23

∴ Case (4) is satisfied → ($\frac{\boldsymbol{Av}}{\boldsymbol{S}}$) = $\frac{\boldsymbol{Vs}}{(\boldsymbol{fy_{t}}*\boldsymbol{d})}$

Vs = ($\frac{Vu}{\phi}$ - Vc)

Vs= $(\frac{31.9}{0.75}-\frac{22.79}{0.75})$ = 12.146 KN

Try 2 Φ 10 = 2 * 78.5 = 157.1 mm^2.

Try Ø 10 With 2 Legs with As =157.1 mm2

S = (Av * f_{yt} * d)/Vs

= (157.1 * 420 *282) / (12.146 *10^3) = 1530.96mm

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

S max < 141 mm OR S max < 600 mm

S max < 141 ……….. **Control**

S max = 141 mm < 1530.96 mm

TAKE S= 140 mm

USE Ø 10 With 2 Legs / 140 mm

4.8 Design beam

4.8.1 Section details and loads

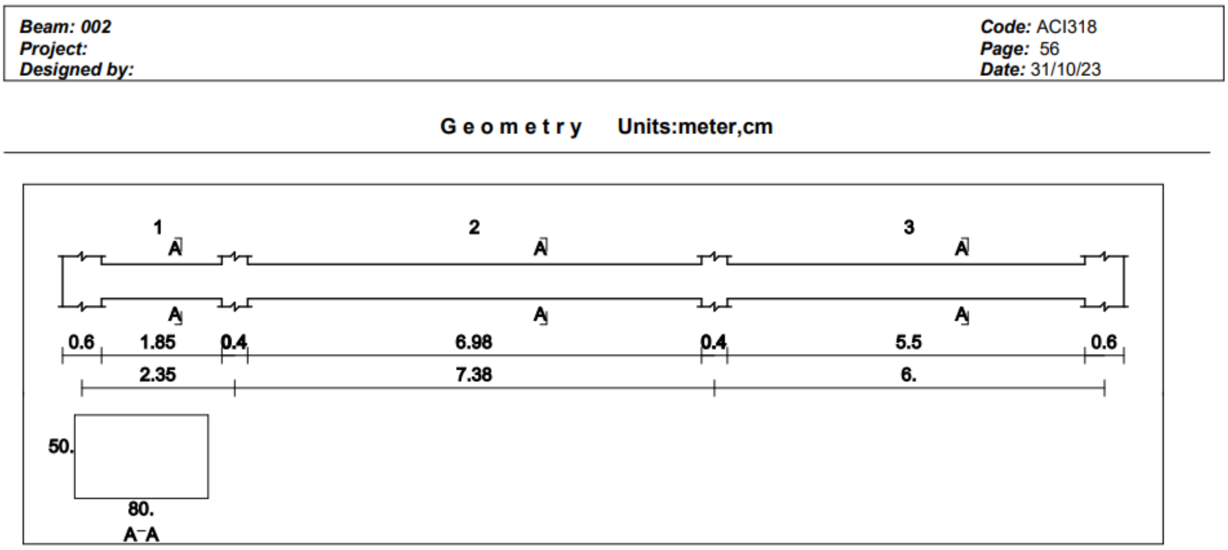


Figure 4-7: Beam B002 Section Detail

✓ **Material:**

concrete B300 Fc’ = 24 N/mm^2

Reinforcement Steel Fy = 420 N/mm^2

✓ **Section:**

B = 80 cm

h =50 cm “choose h= 50cm, for deflection requirement’s L/240”

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

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

=600 /18.5 =32.4 cm.

h_{min} for both end cont. = L/21

=738 /21 = 35 cm.

Select Total depth of beam h= 50cm.

- ✓ Loads acts on beam B002:
- Reactions from (rib 007):

D.L = 34.69/0.52 = 66.7 kN/m

L.L = 18.41/0.52 = 35.4 kN/m

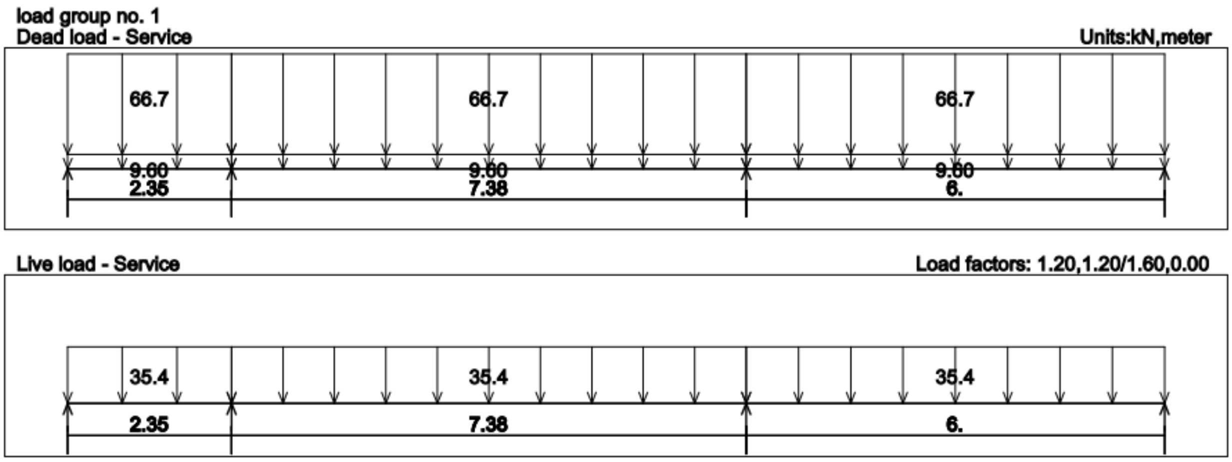


Figure 4-8: Beam B002 Loads Detail

4.8.2 Design for flexure

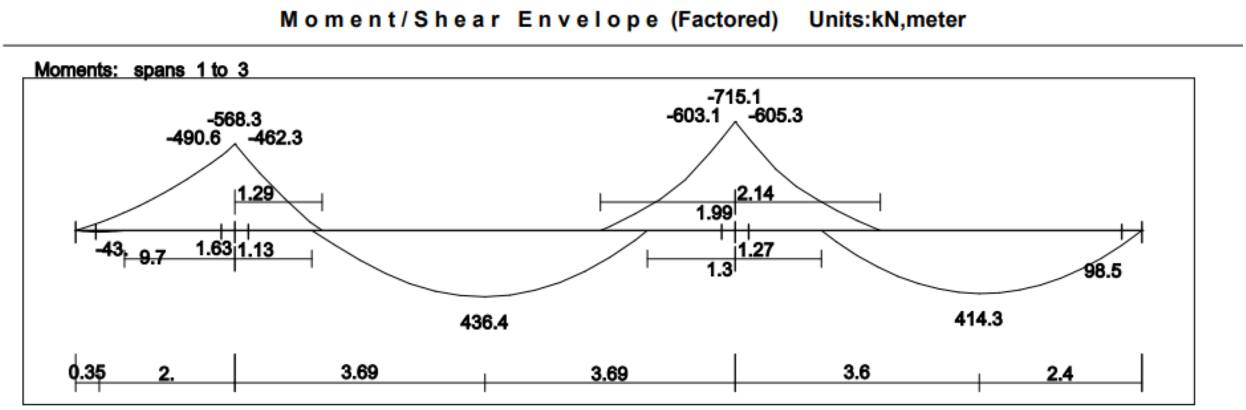


Figure 4-9: Beam B002 Momont Envelope diagram.

✓ (Mu_{max} = 436.4 kN.m)

Assume bar diameter **Ø20** for main reinforcement.

Assume bar diameter **Ø10** for stirrups.

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

$=500 - 40 - 10 - \frac{20}{2} = 440$ mm

$C_{max} = \frac{3}{7} * d = \frac{3}{7} * 440 = 188.6$ mm.

$a_{max} = \beta_1 * C_{max} = 0.85 * 188.6 = 160.31$ mm.

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

$= 0.85 * 24 * 800 * 160.31 * (440 - 160.31/2) * 10^{-6} = 941.447$ KN.m

$\varepsilon_s = 0.003 * \frac{d-c}{c} = 0.003 * \frac{440-188.6}{188.6} = 0.004$

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

$\phi\, Mn_{max} = 0.82 * 941.447 = 800.229$ KN.m

→ Mu = 290. KN.m < $\phi\, Mn_{max}$ = 800.229 KN.m ∴Singly reinforced concrete section.

✓ Maximum positive moment $Mu^{(+)}$ = 436.4 kN.m

m = 20.6

$R_n = \frac{M_n}{0.9*b*d^2} = \frac{436.4*10^6}{0.9*800*(440)^2} = 3.13$ MPa

$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*3.13}{420}}\right) = 0.008134$

$A_s = \rho * b * d = 0.008134*800*440 = 2863.168$ mm^2

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

$$= \frac{\sqrt{24}}{4 * 420} * 800 * 440 \;\geq\; \frac{1.4}{420} * 800 * 440$$

= 1026.45 mm^2 < 1173.33 mm^2 …. As, min = 1173.33 mm^2

A_s = 2863.168 mm^2 > As, min = 1173.33 mm^2 **OK**

Use 8 ϕ22 …. As= 3041.06 mm^2 for bottom reinforcement

$\boldsymbol{A_{s_{provid}} = 3041.06\ \ mm^2 > A_{s_{req}}} = 2863.168\ \boldsymbol{mm^2}$

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

$a = \frac{A_S \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{3041.06 \times 420}{0.85 \times 24 \times 800} = 78.26$ mm

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{78.26}{0.85} = 92.07$ mm.

d=500 – 40 – 10 – $\frac{20}{2}$ = 440 mm

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{440-92.07}{92.07} * 0.003 = 0.011 > 0.005$ ∴ **ϕ =0.9 … OK**

- ✓ Maximum positive moment $Mu^{(+)}$ = 414.3 kN.m

m = 20.6

$R_n = \frac{M_n}{0.9 * b * d^2} = \frac{414.3 * 10^6}{0.9 * 800 * (440)^2} = 2.97$ MPa

$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 20.6 * 1.97}{420}}\right) = 0.00769$

$A_s = \rho$ * b *d =0.00494*800*440 = 2706.88 mm^2

A_s = 2706.88 mm^2 > As, min = 1173.33 mm^2 **OK**

Use 9 ϕ20 …. As= 2827.44 mm^2 for bottom reinforcement

$\boldsymbol{A_{s_{provid}}} = 2827.44\ \boldsymbol{mm^2 > A_{s_{req}}} = 2706.88\ \boldsymbol{mm^2}$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{2827.44 \times 420}{0.85 \times 24 \times 800}$ = 72.765 mm

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{72.765}{0.85}$ = 85.6 mm.

d=500 – 40 – 10 – $\frac{20}{2}$ = 440 mm

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{440-85.6}{85.6} * 0.003$ = 0.012> 0.005 ∴ **ϕ =0.9 … OK**

- ✓ Maximum positive moment $Mu^{(-)}$ = 605.3 kN.m

m = 20.6

$R_n = \frac{M_n}{0.9 * b * d^2} = \frac{605.3*10^6}{0.9*800*(440)^2}$ = 4.34 MPa

$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*1.97}{420}}\right)$= 0.0011757

$A_s = \rho$ * b *d =0.0011757*800*440 = 4138.464 mm^2

A_s = 4138.464 mm^2 > As, min = 1173.33 mm^2 **OK**

<u>Use 10 ϕ25</u> …. As= 4908.738 mm^2 for bottom reinforcement

$\boldsymbol{A_{s_{provid}}} = 4908.738\, \boldsymbol{mm^2} > \boldsymbol{A_{s_{req}}} = 4138.464 \boldsymbol{mm^2}$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{4908.738 \times 420}{0.85 \times 24 \times 800}$ = 126.33 mm

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{126.33}{0.85}$ = 148.6 mm.

d=500 – 40 – 10 – $\frac{20}{2}$ = 440 mm

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{440-148.6}{148.6} * 0.003$ = 0.007> 0.005 ∴ **ϕ =0.9 … OK**

✓ Maximum positive moment $Mu^{(-)}$ = 490.6 kN.m

m = 20.6

$R_n = \frac{M_n}{0.9*b*d^2} = \frac{490.6*10^6}{0.9*800*(440)^2}$ = 3.52 MPa

$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*3.52}{420}}\right)$= 0.00927

$A_s = \rho * b * d$ =0.00927*800*440 = 3263.04 mm^2

A_s = 3263.04 mm^2 > As, min = 1173.33 mm^2 **OK**

<u>Use 7 ϕ25</u> …. As= 3436.12 mm^2 for bottom reinforcement

$\boldsymbol{A_{s_{provid}}} = 3436.12\ \boldsymbol{mm^2} > \boldsymbol{A_{s_{req}}} = 3263.04\ \boldsymbol{mm^2}$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{3436.12 \times 420}{0.85 \times 24 \times 800}$ = 88.43 mm

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{88.43}{0.85}$ = 104.03 mm.

d=500 – 40 – 10 – $\frac{20}{2}$ = 440 mm

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{440-104.03}{104.03} * 0.003$ = 0.009> 0.005 ∴ **ϕ =0.9 … OK**

4.8.3 Design for Shear

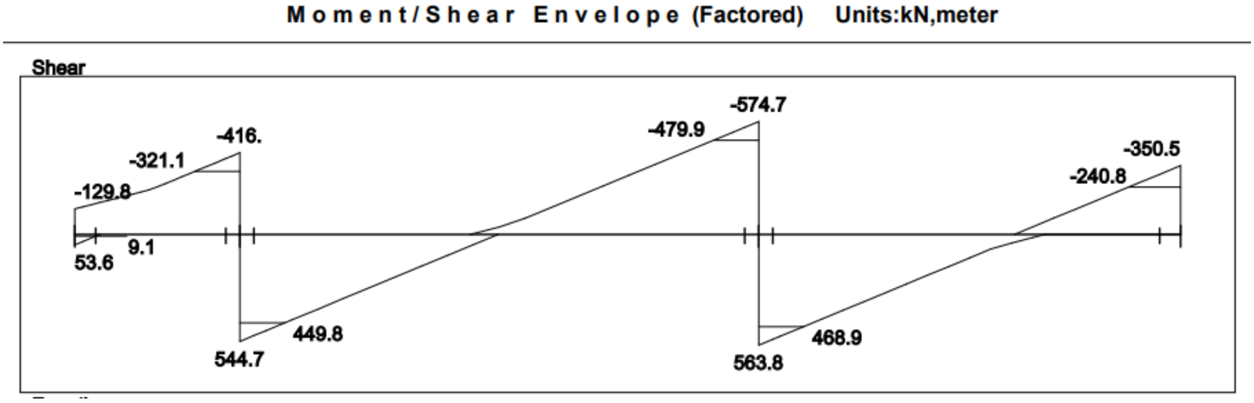


Figure 4-10: Beam B002 Shear Envelope diagram.

✓ $(\boldsymbol{V_{u,d} = 479.9\ KN})$

$\phi Vc = \phi * \frac{\sqrt{f_c'}}{6} * b * d = 0.75 * \frac{\sqrt{24}}{6} * 800 * 440 * 10^{-3} = 215.556$ KN.

Check For Cases:-

<u>Case1</u>: $V_u \leq \frac{\phi V_c}{2}$

$\frac{\phi V_c}{2} = \frac{215.556}{2} = 107.778$ KN

479.9 > 107.778

∴ Case (1) is NOT satisfied.

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

107.778 < 479.9 < 215.556

∴ Case (2) is NOT satisfied.

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

$\phi\, Vs_{min} \geq \frac{\phi}{16}\sqrt{f_c'} * b_w * d = \frac{0.75}{16}\sqrt{24} * 800 * 440 * 10^{-3} = 80.83$ KN.

$\geq \frac{\phi}{3} * b_w * d = \frac{0.75}{3} * 800 * 440 * 10^{-3} = 88$ KN …. **Control**.

$\therefore \phi Vs_{min} = 88$ KN.

$\phi V_c + \phi Vs_{min} = 215.556 + 88 = 303.556$ KN.

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

$215.556 < 479.9 \leq 303.556$ ….

∴ Case (3) is NOT satisfied

Case 4: $(\phi V_c + \phi Vs_{min}) < V_u \leq (V_c + \phi Vs')$

$\phi Vs' = \frac{\phi}{3}\sqrt{f_c'} * b_w * d = \frac{0.75}{3}\sqrt{24} * 800 * 440 * 10^{-3} = 431.11$ KN.

$\phi V_c + \phi Vs' = 215.556 + 431.11 = 646.66$ KN

$303.556 < 479.9 \leq 646.66$

∴ Case (4) is satisfied → $\left(\frac{Av}{S}\right) = \frac{Vs}{(fy_t * d)}$

$Vs = \left(\frac{Vu}{\phi} - Vc\right)$

$Vs = \left(\frac{479.9}{0.75} - \frac{215.556}{0.75}\right) = 352.46$ KN

Try 2 Φ 10 = 2 * 78.5 = 157 mm^2.

Try Ø 10 With 4 Legs whith As =314.159 mm2

S = (Av * fyt * d)/Vs

= (314.159 * 420 *440) / (352.46 *10^3) = 164.718 mm

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

S max < 220 mm OR S max < 600 mm

S max < 220 ……….. **Control**

S max = 220 mm > 164.718mm

TAKE S= 150 mm

USE Ø 10 With 4 Legs / 150 mm

4.9 Design of Stair

✓ **Material :-**

⇒ concrete B300 $Fc' = 24\ N/mm^2$

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

4.9.1 Design of Flight

$h_{min} = L/20$

$h_{min} = 4.14/20 = 20.7$ cm

Take h = 20 cm

The Stair Slope by $\theta = \tan^{-1}(165 / 300) = 28.8$

Dead Load For Flight For 1m Strip:

No.	Material	Quality Density	DL (KN/m)
1	Tile	23	**23*0.03*1*((0.35+0.165)/0.3) = 1.1845KN/m**
2	Mortar	22	**22*0.03*1*((0.3+0.165)/0.3) = 1.023KN/m**
3	C.R	25	**25*0.25*1 / cos 28.8= 5.7KN/m**
4	Plaster	22	**22*0.03*1 / cos 28.8=0.744KN/m**
5	**Stair**	25	**(25\0.3)*((0.165*0.3)\2) = 2.0625KN/m**
			∑ = **10.714** **KN/m**

Table 4-4:Dead Load Calculation of Flight.

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*0.2*1= 5KN/m**	
4	Plaster	22	**22*0.02*1= 0.44KN/m**	
		∑ =	**6.8**	**KN/m**

Table 4-5:Table 4 5:Dead Load Calculation of strip.

Factored Load for Flight:-

W_U = 1.2 ×10.71+ 1.6×4 = 18.83 KN/m

Factored Load for Landing: -

W_U = 1.2 ×6.8+ 1.6×4 = 16.048 KN/m

d

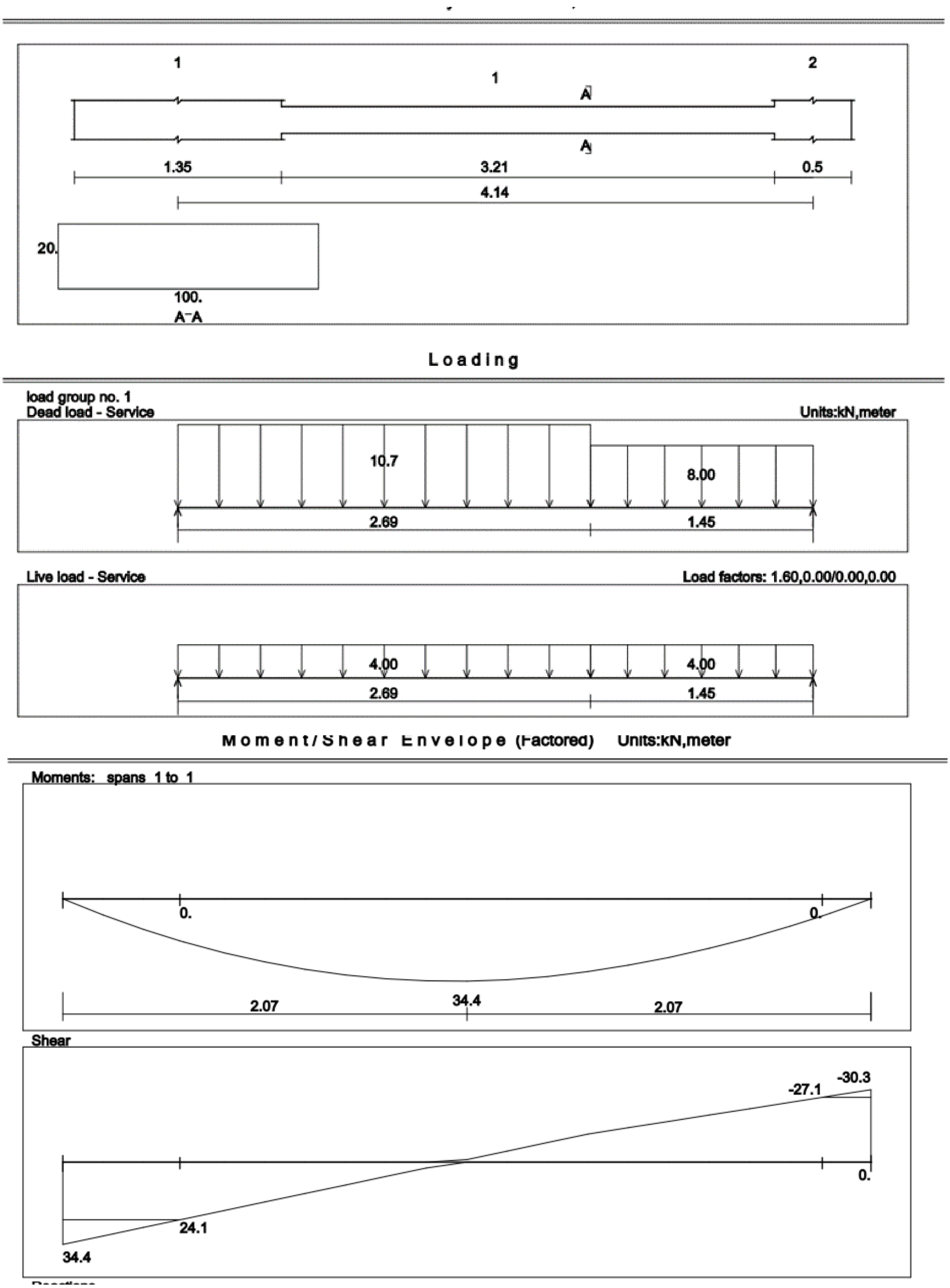


Figure 4-11 : Load & Moment & Shear Envelope deagram for stair flight

✓ design of Shear: (Vu=27.1kn)

Assume bar diameter ø 14 for main reinforcement.

d =h- cover $-\frac{d_b}{2} = 200 - 20 - \frac{14}{2} = 173\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d == \frac{1}{6}\sqrt{24} * 1000 * 173 = 141.254$ KN

$\Phi * V_c = 0.75 * 141.254 = 105.9$ Kn > Vu = 27.1kn

$\frac{\Phi * Vc}{2} = 52.95$ > Vu = 27.1kn **…... No shear reinforcement is required.**

✓ Design of Bending Moment: (Mu= 34.4KN.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)

$= 200 - 20 - \frac{14}{2} = 173$ mm

$R_n = \frac{M_n}{0.9 * b * d^2} = \frac{34.4 \ \ *10^6}{0.9 * 1000 * (173)^2} = 1.277$ MPa

$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 20.6 * 1.277}{420}}\right) = 0.00314217$

As = ρ * b *d =0.00314217*1000*173 = 543.6 mm2 /m

As,min = 0.0018*1000*200= 360 mm2

As,req = 543.6 mm2 > As,min =360 mm2

As,req = 543.6 mm2 ……… is control

$n = \frac{As,req}{As,12} = 4.8$

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

Check for Spacing:

Smax = 3h = 3*200 =600 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 ϕ12/20 cm …. Or 5 ϕ12

$\boldsymbol{A}_{\boldsymbol{s}_{provid}} = 565.487 \text{ mm2 /m} > \boldsymbol{A}_{\boldsymbol{s}_{req}} = 543.6 \text{ mm2 /m}$

✓ 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

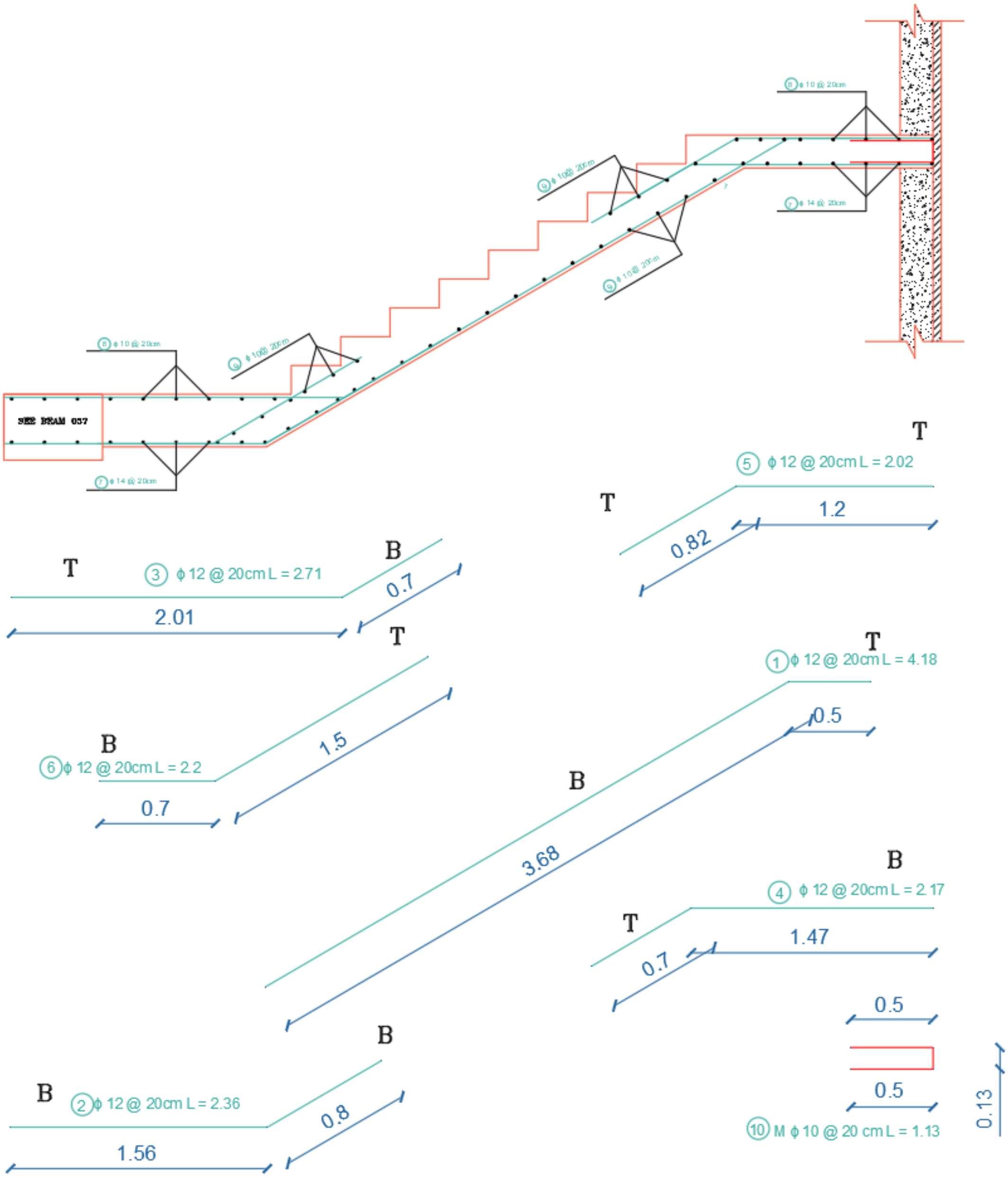


Figure 4-12: Stair flight detailing

4.9.2 Design of Middle Landing

Take h = 20 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*0.2*1= 5KN/m**
4	Plaster	22	**22*0.02*1= 0.44KN/m**
			∑ = **6.8** **KN/m**

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

Factored Load for Landing: -

$W_U = 1.2 \times 6.8 + 1.6 \times 4 = 16.048$ KN/m

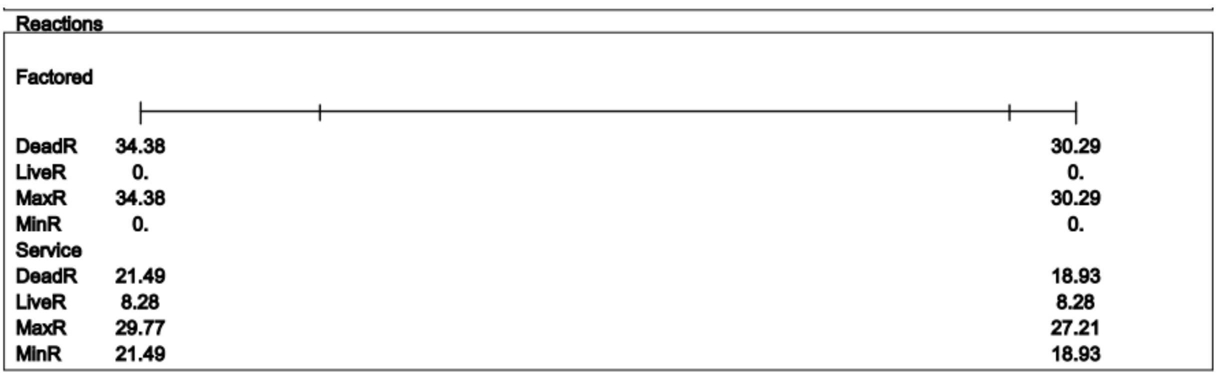
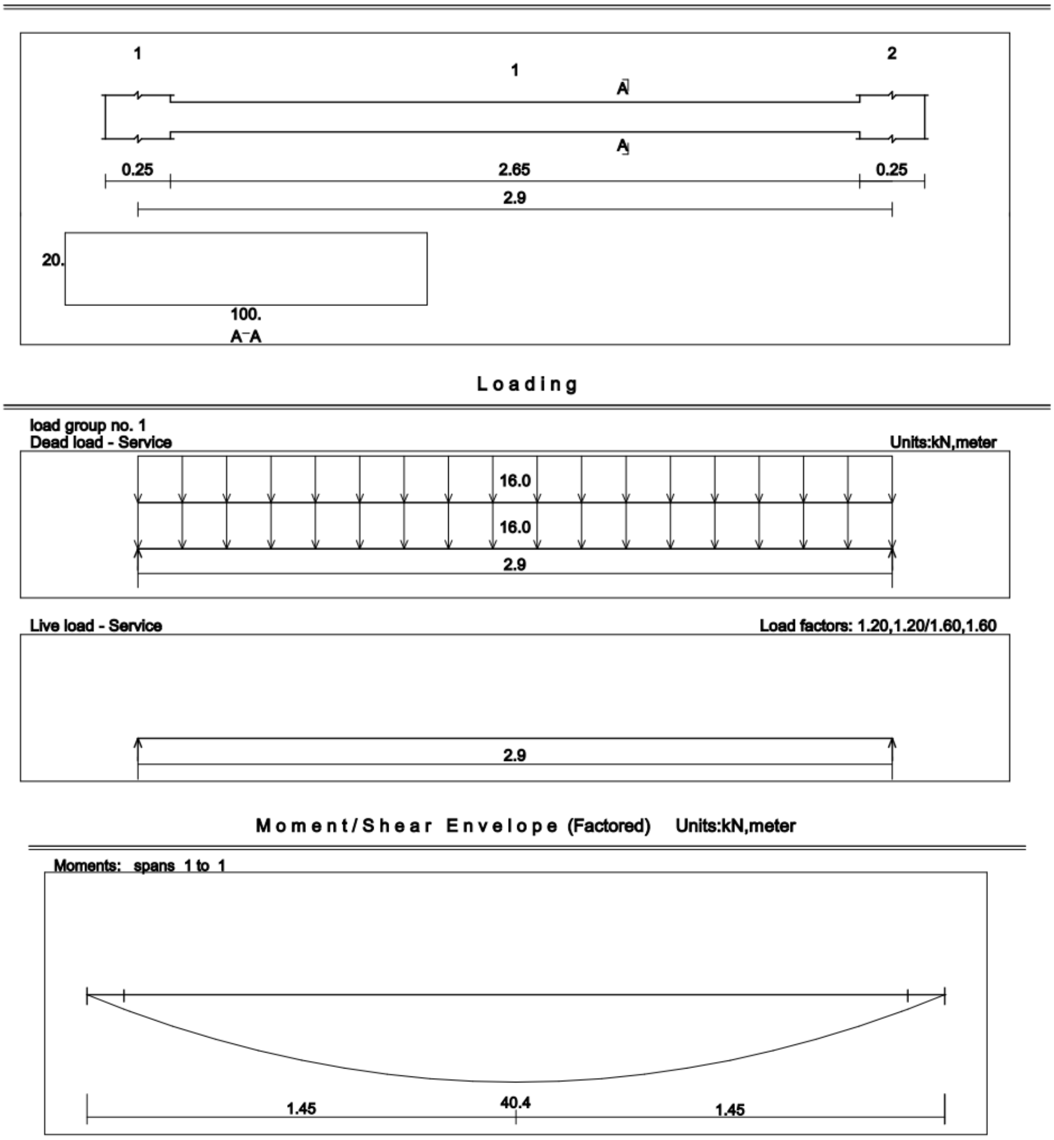


Figure 4-13: Reactions of Middle Landing

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



Slab: 1 2	*Code:* ACI318
Project:	*Page:* 18
Designed by:	*Date:* 13/01/24

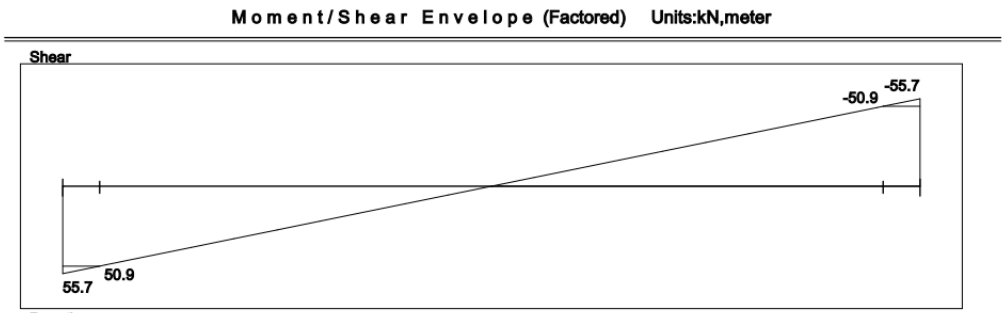


Figure 4-14:Load & Moment Envelope & Shear Envelope diagram for Middle Landing

✓ design of Shear:- (Vu=50.9 kn)

Assume bar diameter ø 14 for main reinforcement

d =h- cover $- \frac{d_b}{2} = 200 - 20 - \frac{14}{2} = 173\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d = = \ \frac{1}{6}\sqrt{24} * 1000 * 173 = 141.254$ KN

$\Phi * V_{c\,=}$ 0.75* 141.254 = 105.9 Kn > Vu = 50.9 kn

$\frac{\Phi * Vc}{2}$ = 52.95 > Vu = 50.9 kn **…... No shear reinforcement are required**

✓ Design of Bending Moment:- (Mu= 40.4 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)

$=200 - 20 - \frac{14}{2} = 173$ mm

$R_n = \frac{M_n}{0.9 * b * d^2} = \frac{40.4 \ * 10^6}{0.9 * 1000 * (173)^2} = 1.5$ MPa

$\rho = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 20.6 * 1.5}{420}}\right) = 0.0031714$

$A_s = \rho$ * b *d =0.00314217*1000*173 = 642.43 m^2 /m

$A_{s,min}$ = 0.0018*1000*200= 360 mm^2

$A_{s,req}$ = 642.43 mm^2 > $A_{s,min}$ =360 mm^2

As,req = 642.43 mm2 ……… is control

$n = \frac{As,req}{As,14} = 4.1$

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

Check for Spacing:-

Smax = 3h = 3*200 =600 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 5 ϕ14

$A_{s_{provid}} = 769.7$ mm2 /m $> A_{s_{req}} = 642.43$mm2 /m

✓ 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

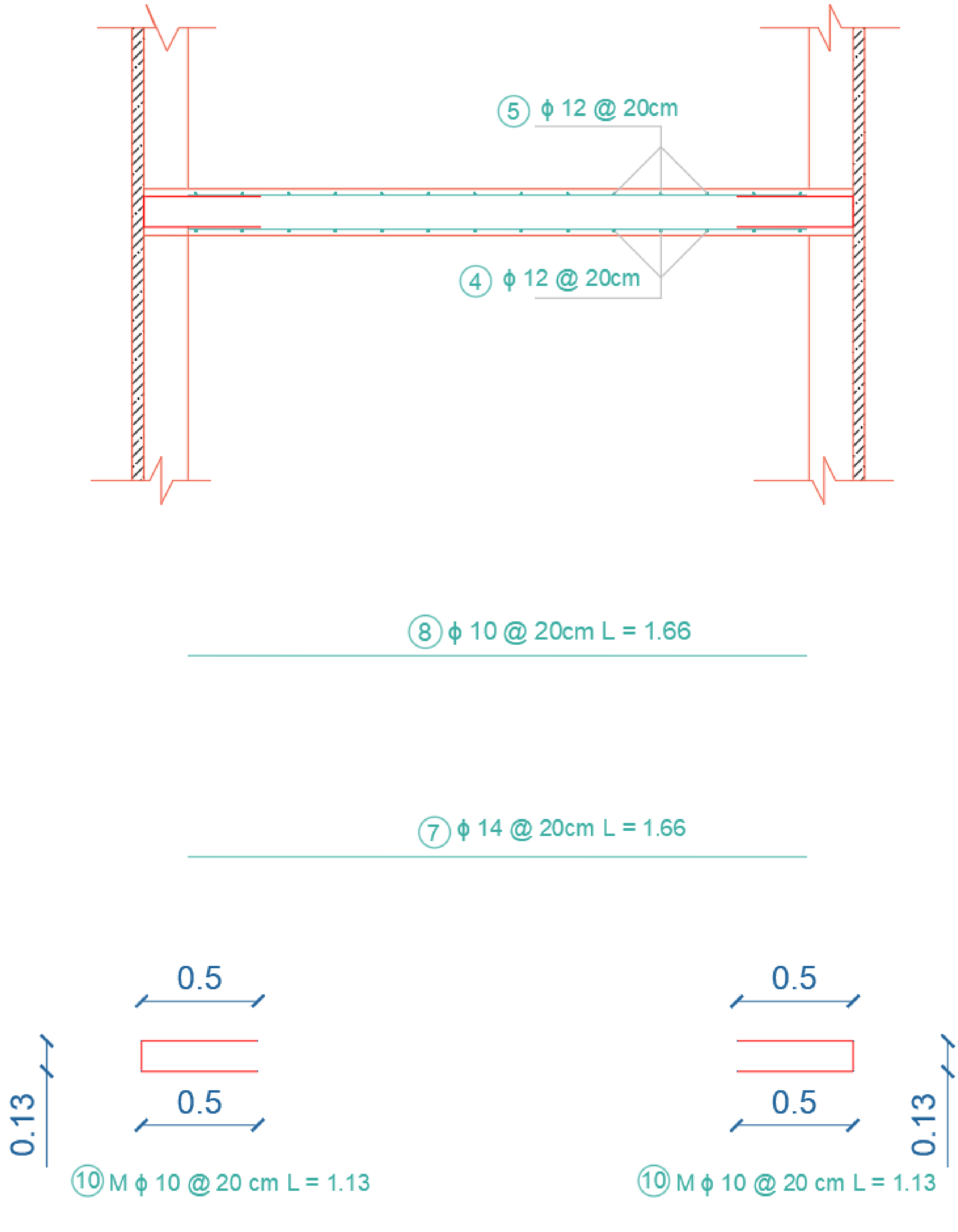


Figure 4-15:Middle Landing detailing

4.10 Design of Column C3

✓ Material :-

⇒ concrete B350 Fc' = 28 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

✓ Load Calculation:-

Service Load:-

Dead Load =3630.42KN

Live Load =1291KN

Factored Load:-

P_U = 1.2 ×3630.42+ 1.6×1291=6422.2KN

✓ 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 318-2002 (10.10.6.3) 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 = 2.7 - 0.6= 2.1 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

$$\frac{1 \times 2.1}{0.165} = 12.7 < 22$$

Column Is Short About X-axis

about Y-axis (b= 0.70m)

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

ry = 0.3b = 0.3 * 0.7 = 0.21

$$\frac{1 \times 2.85}{0.21} = 10 < 22$$

Column Is Short About Y-axis

✓ Dimensions of Column:-

Po = $\frac{Pu}{0.52} = \frac{6422.2}{0.52} = 12350.385$

f = 0.0134

Ag = $\frac{\text{Po}}{0.85\text{fc }(1-f)+f*\text{fy}}$

Ag = $\frac{12350.38462 * 10-3}{0.85*28\ (1-0.0134)+0.0134\ *420}$

= 424279.4558

Select 550 * 800

Ag = 800 * 550 = 440000 > 424279.4558 ….. OK

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

Ast = $\frac{(\ 12350.38462 * 10-3\ ) - 0.85*28*\ 440000}{fy-\ 0.85\ *28}$

= 4741.00106

Use 12 ø 25

Ast 12 ø 25 = 5890.486225

$f = \frac{\text{Ast}}{Ag} = \frac{5890.486225}{440000} = 0.0134 > 0.1 \ldots\ldots OK$

✓ Check For Spacing Between Bars: -

X-axis ..

$S = \frac{550-(40*2)-(2*10)-(3*25)}{2}$ **= 187.5 mm > 150 mm use S hook ..**

Y-axis

$S = \frac{800-(40*2)-(2*10)-(5*25)}{4}$ **= 143.75 mm < 150 mm use S hook ..**

✓ Spacing Between Straps:-

Select smallest ..

S = 48 ds = 48 * 10 = 480 mm

S = 16 db = 16 * 25 = 400 mm

S = $\frac{550}{2}$ = 275 mm …. Cont

Select S = 200 mm

Use One Straps and Tow S hook @ 200 mm

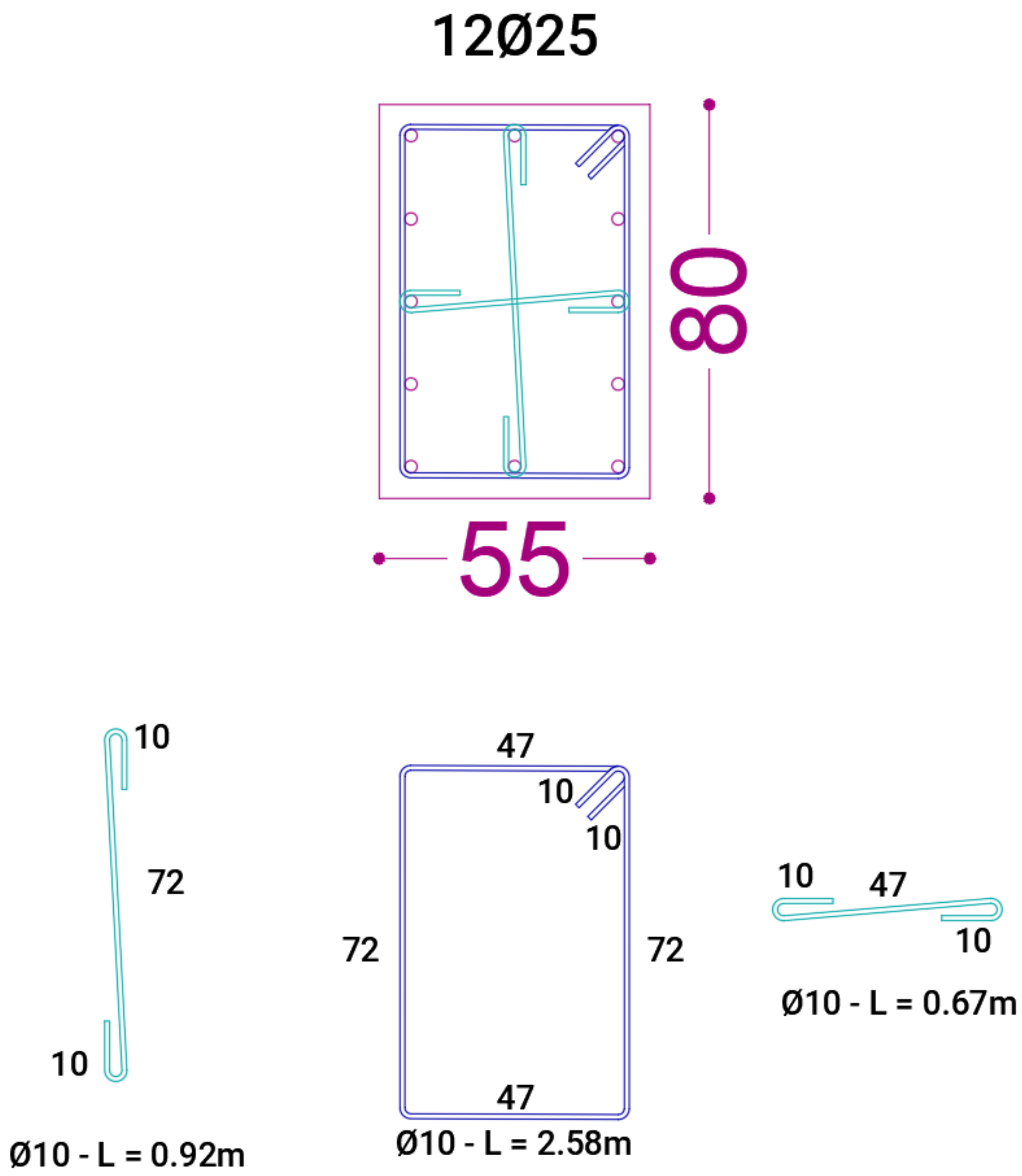


Figure 4-16 : Column C3 Detailing

4.11 Design of Basement wall

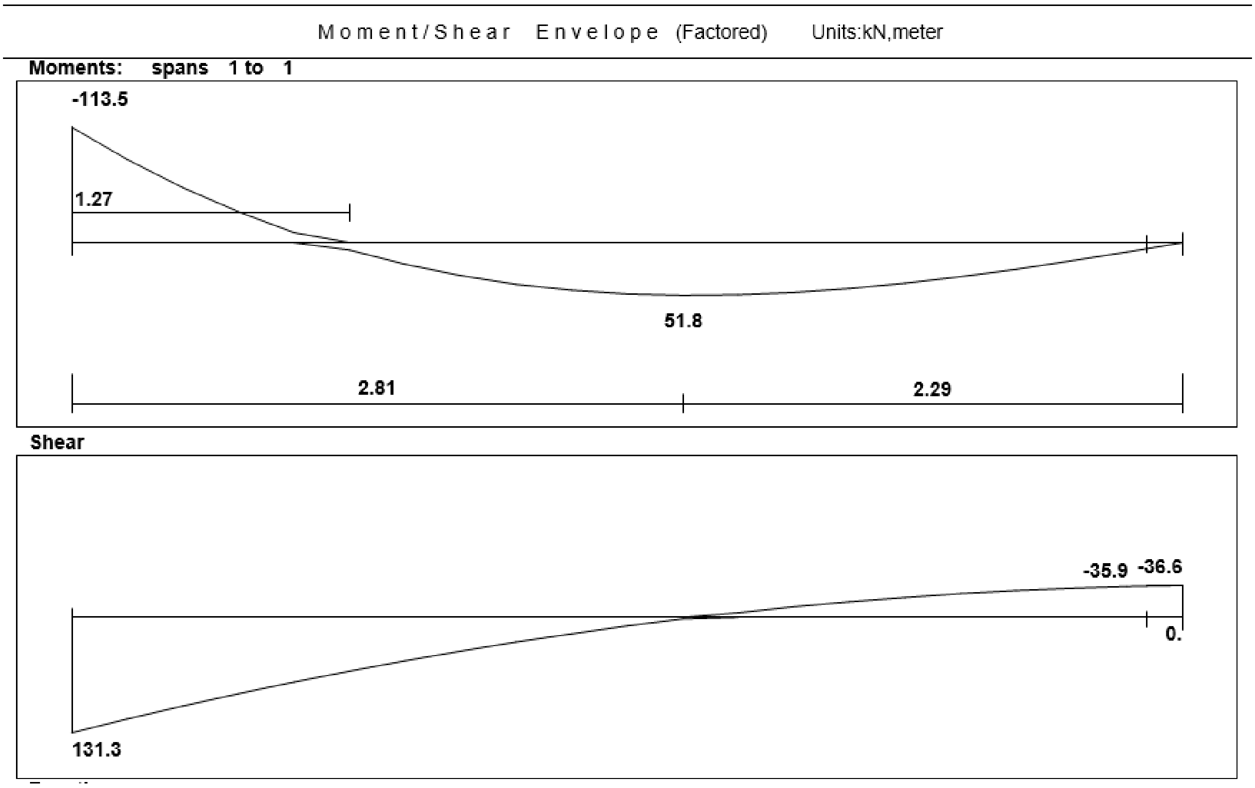


Figure 4-17: Moment & Shear Envelope deagram for Basement Wall

✓ Maximum moment $Mu^{(-)}$ = 113.5 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)

$$=300 - 70 - \frac{16}{2} = 222 \text{ mm}$$

$$R_n = \frac{M_n}{0.9*b*d^2} = \frac{113.5 \ *10^6}{0.9*1000*(222)^2} = 2.22 \text{ MPa}$$

$$\rho = \frac{1}{17.6}\left(1 - \sqrt{1 - \frac{2*17.6*2.22}{420}}\right) = 0.00666$$

$A_s = \rho * b * d = 0.00666*1000*222 = 1479.2 \text{ mm}^2 / \text{m}$

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

$$= \frac{\sqrt{28}}{4*420} * 1000 * 222 \geq \frac{1.4}{420} * 1000 * 222$$

= 699.23 mm^2 /m < 740 mm^2 /m …. As, min = 740 mm^2 /m

A_s = 1479.2 mm^2 > As, min = 740 mm^2 **OK**

Use ϕ16/10cm …. As= 2010.62 mm^2 /m for Negative reinforcement

$$\boldsymbol{A_{s_{provid}}} = 2010.62 \quad \text{mm2 /m} > \boldsymbol{A_{s_{req}}} = 1479.2 \text{ mm2 /m}$$

- ✓ Maximum positive moment $Mu^{(+)}$ = 51.8 kN.m

$$R_n = \frac{M_n}{0.9*b*d^2} = \frac{51.8 \ *10^6}{0.9*1000*(222)^2} = 1.16 \text{ MPa}$$

$$\rho = \frac{1}{17.6}\left(1 - \sqrt{1 - \frac{2*17.6*1.16}{420}}\right) = 0.00285$$

As = ρ * b *d =0.00285*1000*222 = 633.12 mm2 /m

As = 633.12 mm2 < As, min = 740 mm2

➔ As, min = 740 mm2 .... **control**

Use ϕ16/25cm …. As= 803.84 mm^2 /m for Positive reinforcement

$$\boldsymbol{A_{s_{provid}}} = 803.84 \text{ mm2 /m} > \boldsymbol{A_{s_{req}}} = 740 \text{ mm2 /m}$$

- ✓ **Design for Shear**

- ✓ $(\boldsymbol{V_{u,d} = 131.3\ KN})$

$\phi Vc = \phi * \frac{\sqrt{f_c'}}{6} * b * d = 0.75 * \frac{\sqrt{28}}{6} * 1000 * 222 * 10^{-3} = 146$ KN.

$V_u \le \phi V_c$

$131.3 < 146$

Thickness is ok .....

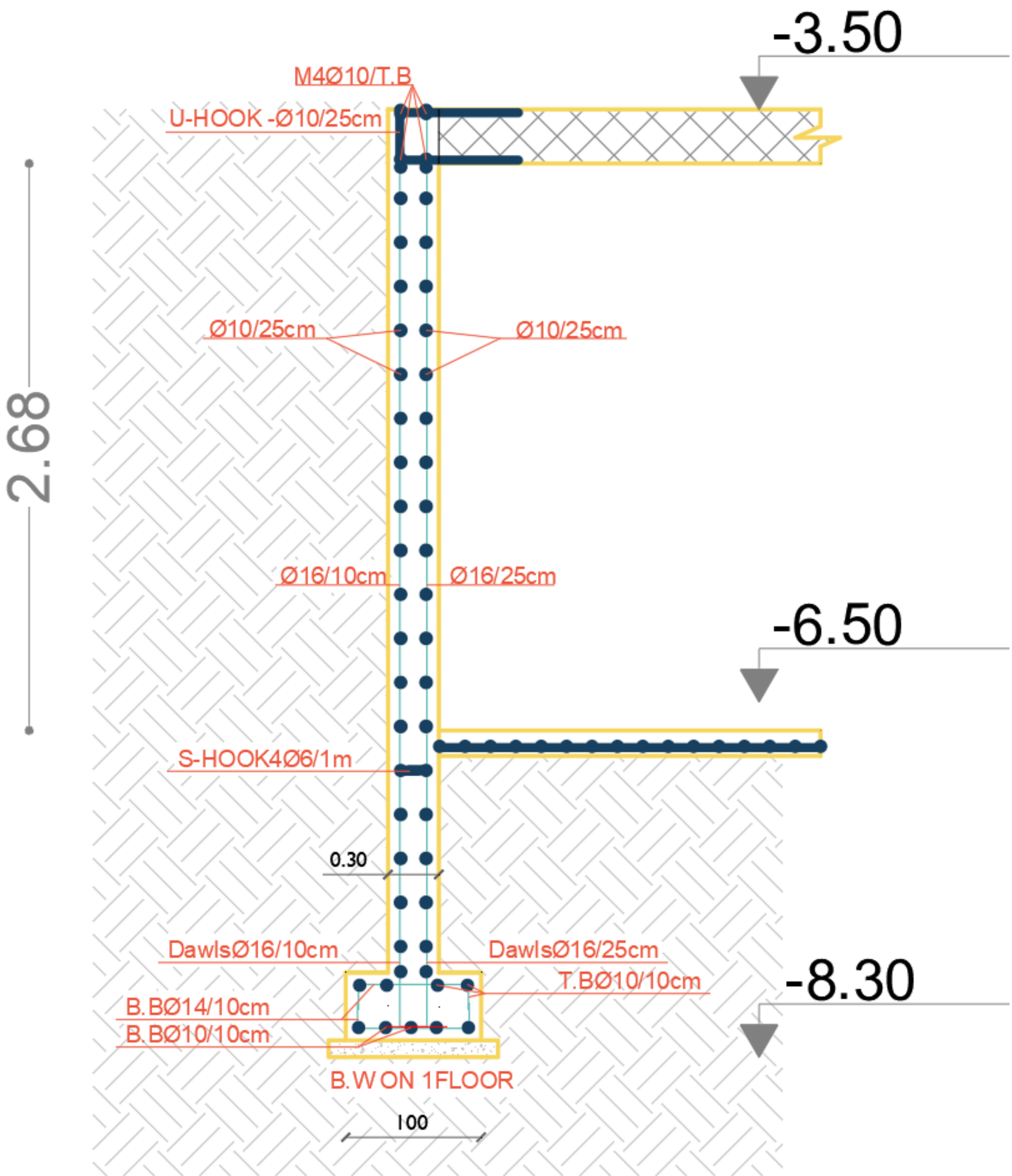


Figure 4-18 : Basement Wall detailing

4.12 Design of Footing (F1)

✓ Material :-

⇒ Concrete B350 Fc' = 28 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

✓ Load Calculations

Dead Load =5936.2 KN, Live Load = 2115.84 KN

Total services load = 5936.2+ 2115.84 = 8051.54 KN

Total Factored load = 1.2*5935.7 + 1.6*2115.84 = 10508.184 KN

Column Dimensions (a*b) =100*70 cm

Soil density = 17 Kg/cm3

Allowable Bearing Capacity = 450 Kn/m2

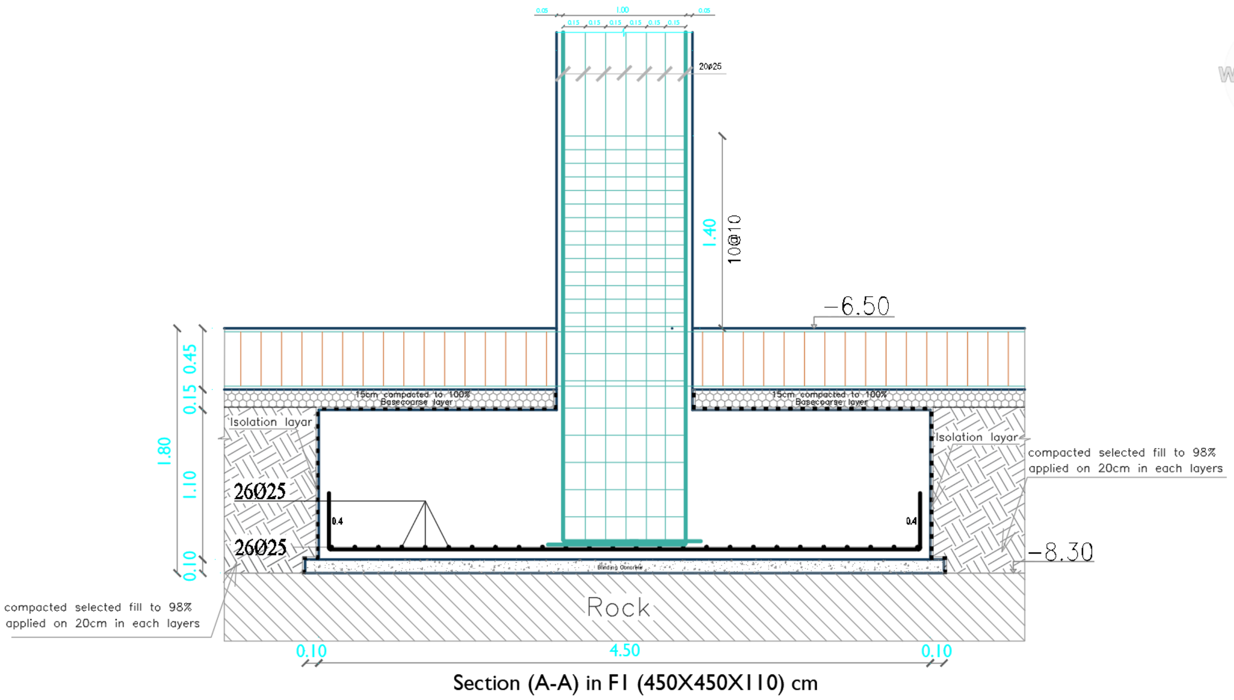


Figure 4-19: Footing F1 Section detailing

Assume h = 110 cm

$q_{net-allow}$ = 450 – (17*0.6 – 25*1.1 – 5) = 407.3

✓ Area of Footing :-

$$A = \frac{Pn}{q_{net-allow}} = \frac{8051.54}{407.3} = 19.76m^2$$

Assume Square Footing

B required =4.5 m

Select B = 4.5 m

✓ Bearing Pressure :-

q_u = 10508.184 /4.5*4.5 = 518.9226 Kn/m^2

✓ Design of Footing:

4.12.1 Design of One-Way Shear Strength:

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

Assume h = 110 cm, bar diameter ø 25 for main reinforcement and 7.5 cm Cover

$d = 1100 – 75 – \frac{25}{2} = 1012.5$ mm

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

$Vu = 518.9226 * \left(\frac{4.5-0.7}{2} - 1.0125\right) * 4.5 = 2072.447$kn

$$\varphi.Vc = \varphi.\frac{1}{6} * \sqrt{fc'} * b_w * d$$
$$\varphi.Vc = 0.75 * \frac{1}{6} * \sqrt{28} * 4500 * 1012.5 = 3013.67Kn$$
$$\varphi.Vc = 3013.67KN > Vu = 2072.447Kn$$

$\therefore Safe$

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

$Vu = Pu - FR_b$

$FR_b = q_u *$ area of critical section

Vu=518.9226*(4.5*4.5-((1+1.0125) *(0.7+1.0125)) = 8719.762612 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:

$$\beta_C = \frac{Column \quad Length \quad (a)}{Column \quad Width \quad (b)} = \frac{10}{7} = 1.42857$$

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

$$b_o = 2 * (1 + 1.0125) + 2 * (0.7 + 1.0125) = 7.45m$$

α_s = 40 for interior column

$$\varphi.V_C = \frac{1}{6}\left(1 + \frac{2}{\beta_c}\right) = \frac{1}{6} * \left(1 + \frac{2}{1.42857}\right) = 0.4$$

$$\varphi.V_C = \frac{1}{12}\left(\frac{\alpha_s * d}{b_o} + 2\right) = \frac{1}{12} * \left(\frac{40 * 1012.5}{7450} + 2\right) = 0.6196$$

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

$$\varphi.V_C = \varphi.\frac{1}{3}\sqrt{f_c{}'}\,b_o d = \frac{0.75}{3} * \sqrt{28} * 7450 * 1012.5 * 10^{-3} = 9978.616Kn$$

ΦVc =9978.616 Kn > Vu=8719.762612 kn

4.12.3 Design for Flexure

Critical Section at the Face of Column

Mu = 518.922*4.5*1.9*1.9/2 = 4214. 9439Kn.m

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{4214.9439\times10^6}{0.9\times4500\times1012.5^2} = 1.015188 Mpa$

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

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{17.65}\left(1-\sqrt{1-\frac{2\times17.65\times1.015188}{420}}\right) = 0.002470988$

$A_{s,req}$ = ρ.b.d =0.002470988×4500×1012.5= 12009.00168 mm^2

$A_{s,min}$ = 0.0018*4500*1100= 8910 mm^2

$A_{s,req}$ = 12009.00168 mm^2 > $A_{s,min}$ =1080 mm^2

As,req = 12009.00168 mm2 ……… is control

n = $\frac{12009.00168}{AS\ 25}$ **= 24.46**

<u>Use 25ø25in Both Direction</u>

Check for Spacing:

$S = \frac{\mathbf{4500-(75*2)-(25*25)}}{\mathbf{24}}$ **= 155.2**

S = 3h = 3*110 = 330cm

S = 45 cm ……… **is control**

Smax = 45 cm > S= 15.2 cm → OK

4.12.4 Design of Dowels:

Load Transfer in Footing:

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

$A_1 = 1 * 0.7 = 0.7\ m^2$
$A_2 = 4.5 * 4.5 = 20.25\ m^2$

$$\sqrt{\frac{A_2}{A_1}} = \sqrt{\frac{20.25}{0.7}} = 5.37 > 2 \ldots\ldots\ldots\ldots\ldots \sqrt{\frac{A_2}{A_1}} = 2$$

$$\Phi Pn.b = 0.65 \times (0.85 \times fc \times A1 \times \sqrt{\frac{A_2}{A_1}})$$
$$\Phi Pn.b = 0.65 \times (0.85 \times 28 \times 700 \times 2) = 22657.6Kn$$

$$0.65 \times (0.85 \times fc \times A1)$$
$$= 0.65 \times (0.85 \times 28 \times 700) = 11328.8$$

$$\Phi Pn = 11328.8 > Pu = 10508.184 \ldots\ldots\ldots\ldots ok$$

As,min = 0.005*A1
= 0.005 * 700*1000
= 3500 m^2

n $= \frac{3500}{AS\ 25} = 7.13$

Use 8 ø 25

As=3926.99 mm^2 > As,min = 3500 m^2

Select Dowels reinforcement 20 ø 25 Same # of Bars in columns.

4.13 Seismic Design

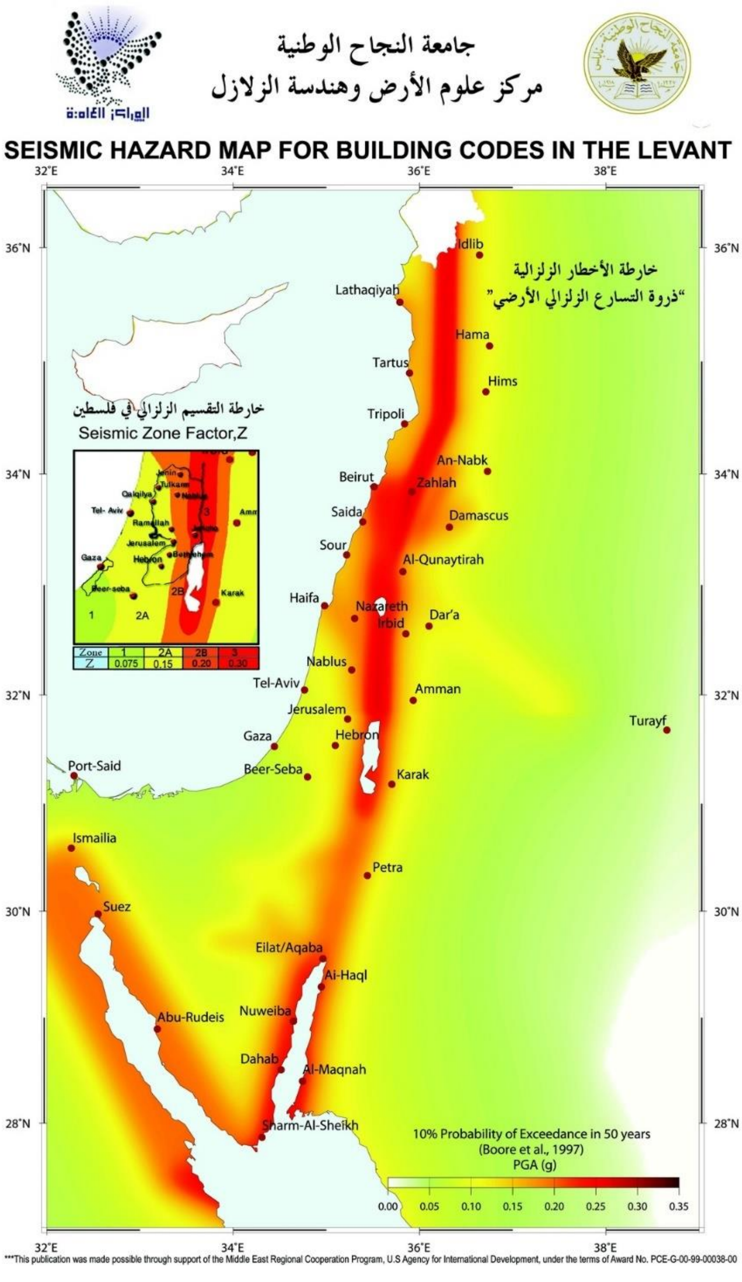


Figure 4-20 : Seismic Hazard Map For Building Codes in Palestine

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 4-7 : 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 4-8 : Values of Approximate Period Parameters C_t & 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					
	$S_S \le 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S = 1.25$	$S_S \ge 1.5$
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 4-9: Short-Period Site Coefficient F_a (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 4-10: 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 4-11: 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 4-12 : 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 4-13 : 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 4-14 : 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, Ω_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 4-15 : 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 Ω= 2.5 C_d=4.5

✓ Select Permitted Analytical Procedures :

Table 12.6-1 Permitted Analytical Procedures

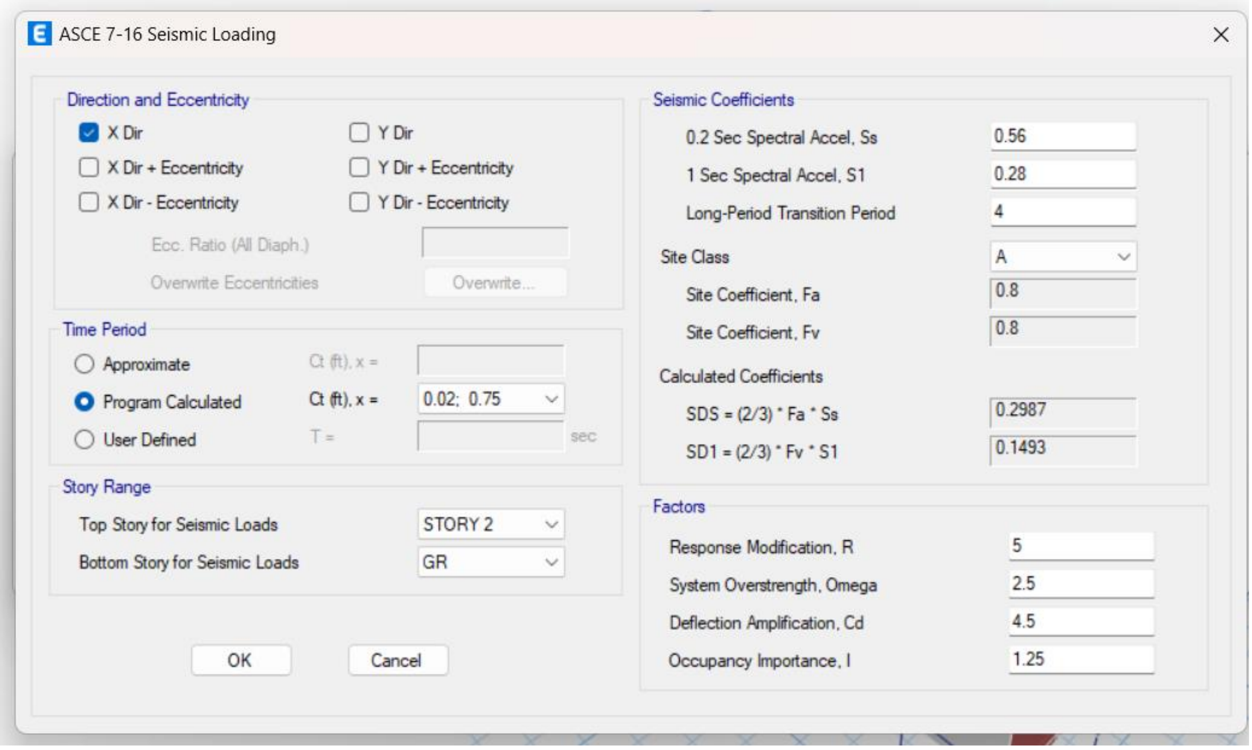
Seismic Design Category	Structural Characteristics	Equivalent Lateral Force Procedure, Section 12.8[a]	Modal Response Spectrum Analysis, Section 12.9.1, or Linear Response History Analysis, Section 12.9.2[a]	Nonlinear Response History Procedures, Chapter 16[a]
B, C	All structures	P	P	P
D, E, F	Risk Category 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 4-16 : 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
" REFERENCES "

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