Palestine Polytechnic University

Faculty of Engineering

Department of Civil and Architectural Engineering

Project Name:

The Structural Design for Halhul Arabic Language Complex.

Team members:

Aya Alzeer Ayat Dadoa

Supervision:

Eng. Inas Shweiki

Palestine – Hebron

2020

Abstract

The Structural Design for Halhul Arabic Language Complex.

The Structural design is the most important design of any building after the necessary of architectural design, the distribution of columns, loads, offer durability, the best prices and the highest degree of safety are the responsibility of the structural designer. In this project we will do the structural design of the "Halhul Arabic Language Complex".

It is important mentioning that we will use the Jordanian Code to determine the live loads, for the analysis of the structural and design sections we will use (ACI_318_11) code, it must be noted that we will be relying on some computer programs such as:(AutoCAD, Safe, , Attir, Etabs, Office).

يعد التصميم الإنشائي هو التصميم الأكثر أهمية لأي مبنى بعد ما يلزم من تصميم معماري ، وتوزيع الأعمدة ، والأحمال وقوة العرض ، وأفضل الأسعار وأعلى درجة من الأمان هي مسؤولية المصمم الإنشائي. في هذا المشروع سنقوم بتصميم المنشأ (مجمع اللغة العربية في حلحول) هيكليا وانشائيا .

تجدر الإشارة إلى أننا سنستخدم الكود الأردني (ACI_318_11) لتحديد الأحمال الحية ، لتحليل الأقسام الهيكلية والتصميم التي سنستخدمها ، يجب الإشارة إلى أننا سوف نعتمد على بعض برامج الحاسوب مثل:

(AutoCAD, Attir, Safe, Etabs, Office)

الاهداء

الى الوطن الذي تبدأ حدوده من العين دون أن تجد لها نهاية

الى القضية الراسخة فينا كالدم ،والأرض التي منها جبلنا وفي ترابها سندفن

الى حقنا الذي لن يضيع وصوتنا الذي لن يسكت

(الى فلسطين كل فلسطين)

الى التي كان لا بد أن يحمل اسمها عنوان بحثي وما احتواها نص يوما

الى التي لا تكيفيني الروح لأهديها لها

الى التي ترقب كل ليلة مصباح المكتب ..ترجو سرعة انطفائه

فينطفأ حينا ...وتسبقه عيناها أحيانا... مشفوعا بوعد الحق من الاله الحق

الى أم من ماء ان حملتني طفوت عاليا وان تركتني غرقت عميقا بين احضانه

اليك (أمي العزيزة)

الى الذي بعينيه أبصر وبقدميه أسير

من اذا عليه ملت أسندني، ومن اذا اليه سرت مخضعا رأسي أسعدني

الى القلب الكبير الذي وهبني الحياة ليس مرة بل مرات لا تحصى

اليك (أبي الحبيب)...

والى أربعة بل خمسة هم من أعطوا الحياة لونا بعد أن كانت رمادية

من أختلف معهم لأحبهم أكثر بعدها... أخاصمهم لينغرس حبهم أكثر فأكثر في قلبي

(أخوتي الأعزاء جدا)

الى أشخاص احضرتهم خمس سنوات ليصيروا عمرنا

أصدقائي الذين لا يمكن لورقة أن تحوي أسماءهم

الى الذين في الله أحبهم

(أصدقائي جميعا)

من علمني حرفا صرت له عبدا

الى الذين يهبوننا أعمارهم لنتعلم، ويقدمون كل ما في وسعهم ، ولا مقابل للعلم غير العلم

الى الهيئة التدريسية جمعاء

والى التي أسموها ب (ايناس)ربما مصادفة لكنها كانت مملوءة صادقة ومحقة

ليكون الاسم على مسماه ...الى يقين لن يخيب يوما

أستاذتنا الفاضلة والمضيئة المهندسة (ايناس شويكي)

والى كل الذين لم تقرأ أسماؤهم وطويت بالقلب

اليكم جميعا نهدي فاتحة العطاء ...على أمل البقاء بإذن الله تعالى.

الشكر

الشكر أولا وأخيرا لله عز وجل من قبل ومن بعد
الذي أتم علينا نعمته ، ومنَ علينا من كرمه وفضله
وعلمنا من علمه ...

وكل الشكر والتقدير لدائرة الهندسة المدنية والمعمارية في جامعة بوليتكنك فلسطين بكوادرها من اداريين وأكاديميين...

ونخص بالذكر المهندسة ايناس شويكي التي رافقتنا خطوة بخطوة يوم كنّا على مفترق الطريق...فلها جزيل الشكر والعرفان ...

وقبل أن نمضي ...وكيف لنا أن نمضي ...قبل أن نتقدم بأسمى آيات الشكر والامتنان والعرفان لأساتذتنا الأفاضل ذوي العقول النيرة...

كما نتقدم بالشكر لزملائنا وزميلاتنا الأفاضل ...الذين رافقونا مسيرتنا هذه طيلة السنوات الخمس الماضية ...ونقول لهم :

" كن عالما... فان لم تستطع فكن متعلما، فان لم تستطع فأحب العلماء، فان لم تستطع فلا تبغضهم ."

وخاتم القول مسك ، فكل الشكر لآبائنا وأمهاتنا... أصحاب الفضل الأكبر و الدور الأبرز في وصولنا الى ما وصلنا اليه ...فها نحن اليوم نقف أمامهم مرفوعي الرأس على عتبات التخرج كما وعدناهم ووعدنا أنفسنا من قبل ...

List of Figures

List of Tables

Table Name **Page Number**

List of Abbreviation

- **Ac =** area of concrete section resisting shear transfer.
- **As =** area of non-prestressed tension reinforcement.
- **Ag =** gross area of section.
- **Av =** area of shear reinforcement within a distance(S).
- **At =** area of one leg of a closed stirrup resisting tension within a (S).
- **b =** width of compression face of member.
- **bw =** web width, or diameter of circular section.
- **DL =** dead load.
- **d =** distance from extreme compression fiber to cancroids of tension reinforcement.
- **Ec =** modulus of elasticity of concrete.
- **Fy =** specified yield strength of non-prestressed reinforcement.
- **I =** moment of inertia of section resisting externally applied factored loads.
- **Ln =** length of clear span in long direction of tow-way construction, measured face-to face of supports in slabs without beams and face to face of beam or other supports in other cases.
- **LL =** live load.
- **Ld =** development length.
- **M =** bending moment.
- **Mu =** factored moment at section.
- **Mn =** nominal moment.
- **Pn =** nominal axial load.
- **S =** spacing of shear or in direction parallel to longitudinal reinforcement.
- **Vc =** nominal shear strength provided by concrete.
- **Vn =** nominal shear stress.

- **Vs =** nominal shear strength provided by shear reinforcement.
- **Vu =** factored shear force at section.
- **Wc =** weight of concrete. (Kg/m^3).
- **k =** is a factor that depends on end condition of column and whether it is braced or unbraced.
- **ln =** unsupported length of column
- **r =** radius of gyration
- $\frac{kln}{r}$**=** slenderness ratio
- **M1& M2 =** factored end moments of the column
- **e min =** minimum eccentricity
- **M min =** minimum moment
- **I g =** gross moment of inertia of the section
- **I_{se} =** moment of inertia of the reinforcement steel
- β_{dns}**=** ratio of maximum factored sustained shear within a story to the total factored shear in that story.
- **EI =** member stiffness
- **Pc=** Euler buckling load
- δ_{ns} **=** moment magnifier factor
- **Cm=** factor
- γ **=** the ratio of the distance between the centers of the outside layers of bars to the overall depth of the column.
- **h min=** Minimum thickness of slab.
- **αf=** The ratio of flexural stiffness of a beam on the beam section to the flexural stiffness of the slab.
- **Afm=** The average value of αf for all beams on the sides panel.

- **Lnc**= Clear span in the long direction measured face to face of the columns or (face to face of beams for slabs with beams.
- **B=** the ratio of the load to the short clear spans.
- **Cad $_{pos}$=** Coefficients for dead load positive moment in short clear length of slabs.
- **Call $_{pos}$=** Coefficients for live load positive moment in short clear length of slabs.
- **S =** Spacing of shear or in direction parallel to longitudinal reinforcement**.**
- **Vc =** Nominal shear strength provided by concrete.
- **Vs =** Nominal shear strength provided by shear reinforcement.

Table of contents

Chapter 3

Chapter 4

Chapter 5

CHAPTER I

PROJECT INTRODUCTION

Project Introduction

1.1. Introduction

1.2. General Identification

1.3. Reasons of choosing the project

1.4. Project objectives

1.5. Standards

1.6. Project problem

1.7. Project procedures

1.8. Project timeline

1.1 Introduction

From the last centuries until nowadays, the Arabic language is in increasing danger because of the difficult living conditions, including the occupation, which tries to obliterate the features of the Arabic language and the identity of the Arab factor and especially the Palestinian. At the same time, we can't neglect the negligence, which is clearly and very clearly by the native speakers. We need to prevent all this from happening by creating a generation of intellectuals interested in Arabic language issues that will be created through the establishment of an Arabic language complex.

1.2 General Identification

This project is Arabic language complex in Halhul, its total area is 11950.26 m2, it provides all requirements needed for this building like: multi – purpose halls, classrooms, computerized rooms, offices, security department, library, meeting and conference rooms, exhibition, Quran memorization and teaching rooms, chapel, cafeteria with sessions, clinic, bathrooms, warehouse.

1.3 Reasons of Choosing Project

The importance of choosing the project refers to several things, the most important thing is to have the skills and knowledge in analysis and design of various structural members in buildings. In addition, to increasing knowledge of the construction of the systems in place in our country, as well as the scientific knowledge and the process followed in the design and implementation of construction projects that lie ahead after graduation in the labor market. One of things that encourage us to choose and do this search is to present this project to the Civil and Architectural Engineering Department at the Faculty of Engineering in Palestine Polytechnic University to meet the terms of graduation and get a bachelor's degree in civil engineering specialty engineering buildings.

1.4 Project Objectives

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

1.4.1 Architectural Objectives

- To protect Arabic language from loss.
- Do the correct translation of the Arabic language and the use of sound words.
- Carrying out free activities that encourage the use of the Arabic language and encourage society of all ages to come and participate in these activities.
- Preserving the Arab heritage, history and cultural activities of our society and the Arab population.
- To give attention for Arab studies.
- To prevent the rise of vernacular.
- It should be focused on the architectural aspects; the architect can make it a historical event through the coordinated blocks and the elements used in the interfaces.

1.4.2 Structural Objectives

The structural objectives of this project are:

- Increasing the ability to choose a structural system that fits well with the objectives of the building.
- To correlate what we have taken in the design courses with the practical thinking.
- To get a new skills and experiences while facing problems and obstacles rising while working in the project, which has not mentioned in the theoretical studying.

1.5. Standards

- Using (ACI_318_11) code.
- Using analysis programs and structural design such as (Attir, safe, Etabs)
- Other programs (Microsoft word, Microsoft power point).

1.6. Project Problem

The problem of this project is the analysis and structural design of all the structural elements of our building. In this field, each element of the structural elements such as (slabs, columns, beams, etc.) will be analyzed by identifying the loads that are placed on it, and then define the dimensions and design of reinforcing required, and by taking the safety factor of the origin in responsible ,then we will work on the plans and drawings of construction elements that are designed to lead this project to be constructed in reality.

1.7. Project procedures

- Study the Architectural designs which are include:(plans, elevations, sections, site plan).
- Study the units structurally to identify structural elements, loads on the buildings, and the selection of appropriate structural system.
- Distribute columns to the chosen structural system.
- Structural analysis of all structural elements of the units.
- Structural design of all structural elements.
- Preparation of construction drawings of the building to remove the executable image.
- Writing project in accordance with the requirements of the construction engineering.

1.8 Project Timeline

.

Table 1.1: The Time Line Table of the Project Stages

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

Figure (1.1): Time Table

Chapter 2

Architectural Description

Architectural Description

2.1 Introduction

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

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

The design process of any building is carried out in several stages until it is completed to the fullest. It starts with the architectural design stage, at this stage, the form of building is determined, in addition to the different functions and requirements for which the building is being constructed are considered. With the aim of achieving the required spaces, dimensions and the location of columns and axis. Also, in this process we have the studying of the ventilation, movement and other functional requirements. After the completion of the architectural design stage, the structural design process begins with the aim of determining the dimensions and characteristics of the structural elements depending on the different loads that are transported through these elements to the foundations and then to the soil.

2.2 An overview of the project

The idea of the project is the structural design of an Arabic language complex in Halhul, at first, we obtained the architectural drawings from the students of the Faculty of Engineering, specializing in architectural engineering at the Polytechnic University of Palestine, in order to make an analytical and detailed study of these architectural plans. The total area of the building is about 11950.26 m2, distributed over four floors as follows: the ground and first floors with 964.65 m2, the second, third, and fourth floors with 3340,32 m2.

2.3 Project site

For the design of any project that’s needs to analyze the proposed site for the project to see if it fits the project.

- Ambient conditions: include noise and vibration and noise, and environmental pollutants must be free of the region, the characteristics of streets surrounding the site in terms of characteristics and dimensions.
- site needs: includes the needs of vehicles, maintenance equipment for the building to avoid danger and make repairs necessary for the building continuously, facilities and public services and the availability and accessibility of the site and sewage networks and water.

2.4 Site importance

Halhul is a town in Hebron Governorate, located six km north of Hebron city in the southern part of the West Bank. It is bordered by Sa'ir and Ash Shuyukh towns to the east, Beit Ummar and Al Arrub Camp to the north, Kharas and Nuba to the west, and Hebron city and Beit Kahil to the south (See map 1).[1]

Figure (2.1): Halhul location and borders

[1] http://vprofile.arij.org/hebron/pdfs/Halhul.pdf

2.5 General climate of the city

The climate is mild with an average annual temperature of 15 degrees, and an average annual rainfall of 500mm. The original ancient village of Halhul, founded by the Canaanites, is derived from a Canaanite word meaning "to tremble (from the cold)".

2.6 Plans Description

The building in its engineering structure depends on the rectangular shape.

Figure (2.2): Site Plan

The building area is [11950.26] m2, and It is distributed over four floors as follows

2.6.1 Ground Floor

The area of the floor is= [964.65] m2.

The floor levels are: +0.0 m, +4.50m.

It contains cinema, theater, makeup room, changing room, storage.

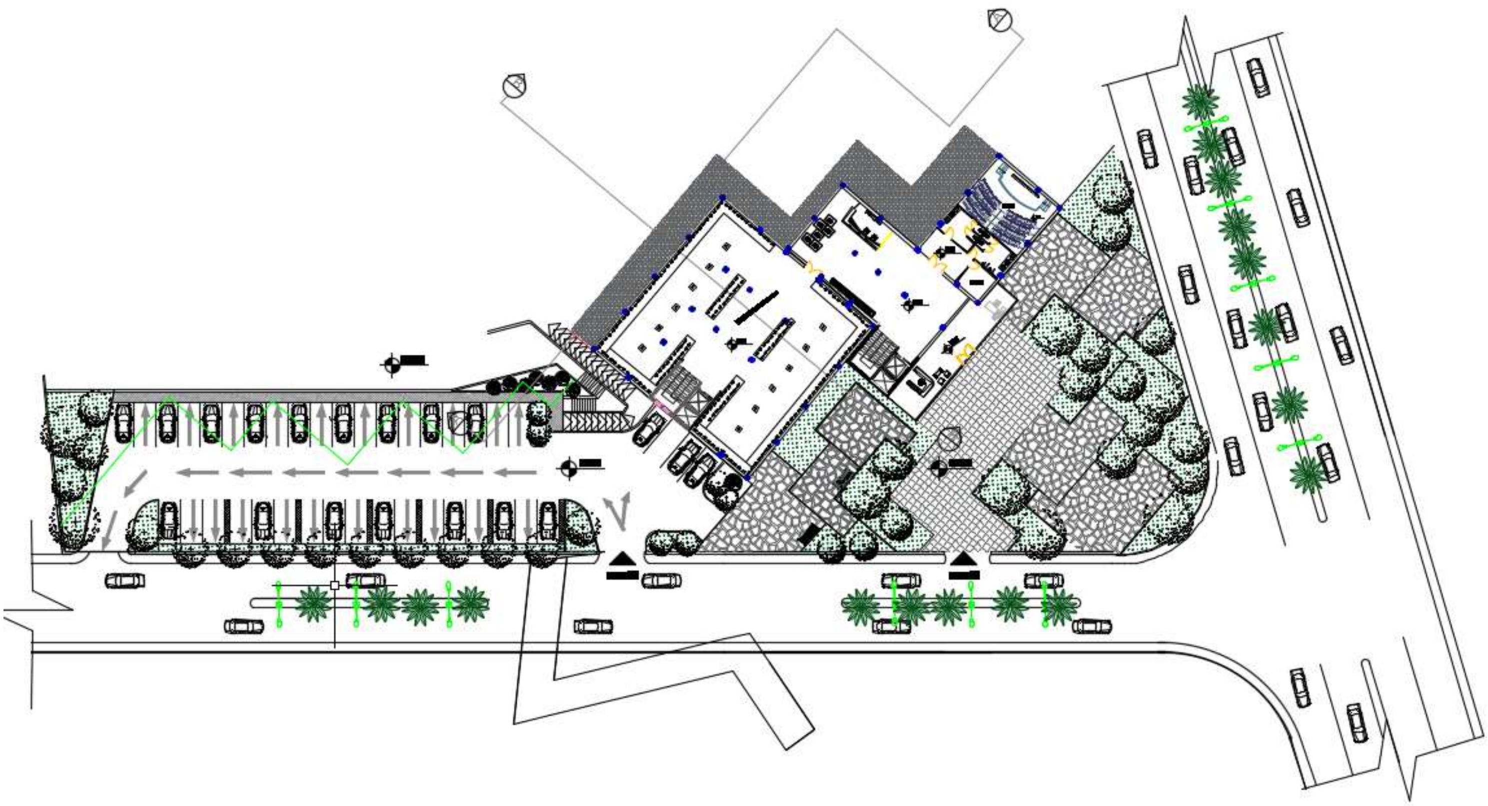


Figure (2.3): Ground Floor

2.6.2 First Floor

The area of the floor is= [964.65] m2.

The floor levels are: +4.50m, +8.00m

It contains: Arabic Language Exhibition, makeup room, changing room, storage.

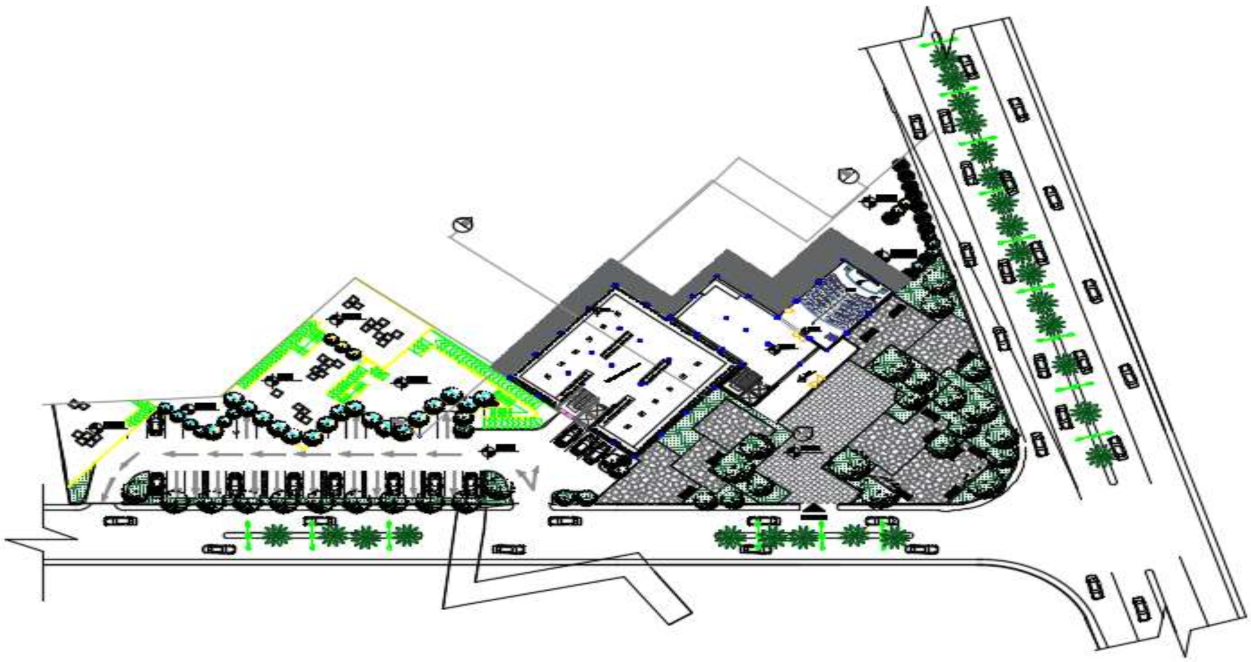


Figure (2.4): First Floor

2.6.3 Second Floor

The area of the floor is= [3340,32] m2.

The floor levels are: +8.0 m

It contains cafeteria, staff cafeteria, clinic, chapel, kitchen, bathrooms, offices, storages, Archives, complex manager room.

Figure (2.5): Second Floor

2.6.4 Third Floor

The area of the floor is= [3340,32] m2.

The floor levels are: +8.00m, + 12.00m

It contains: multi use room, hall of courses rules, hall of intonation courses, poetry courses hall, language teaching hall, computerized room, hall of courses line, exhibition hall, library, archives, kitchen, head of the complex, secretarial, staff offices', meetings hall.

Figure (2.6): Third Floor

2.6.5 Fourth Floor

The area of the floor is= [3340,32] m2.

The floor levels are: +8.00, +12.00m, +15.50m, +15.75, +16.40 m, +17.00m, +18.50m.

It contains: multi use room, hall of courses rules, hall of intonation courses, poetry courses hall, language teaching hall, computerized room, hall of courses line, exhibition hall, library, archives, kitchen, head of the complex, secretarial, staff offices', meetings hall.

Figure (2.7): Fourth Floor

2.7 Project Elevations

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

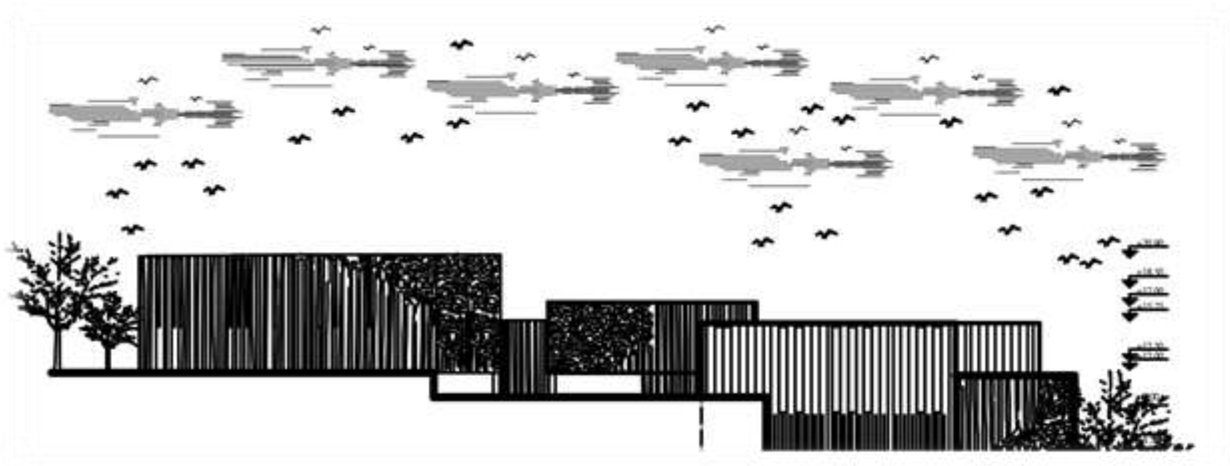


Figure (2.8): Southern Elevation.

Figure (2.9): Western Elevation.

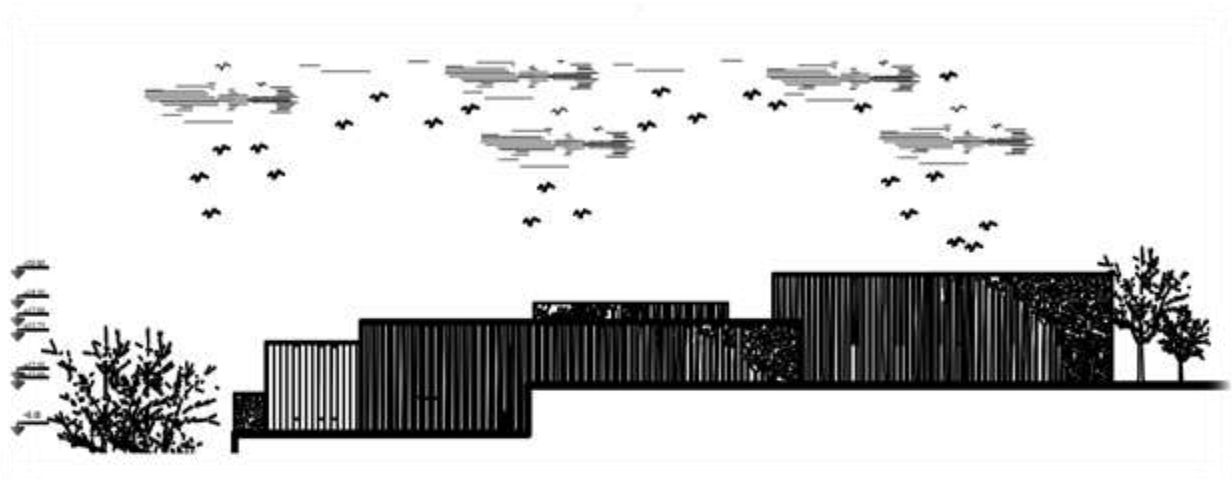


Figure (2.10): Northern Elevation.

Figure (2.11): Eastern Elevation.

2.8 Project Sections

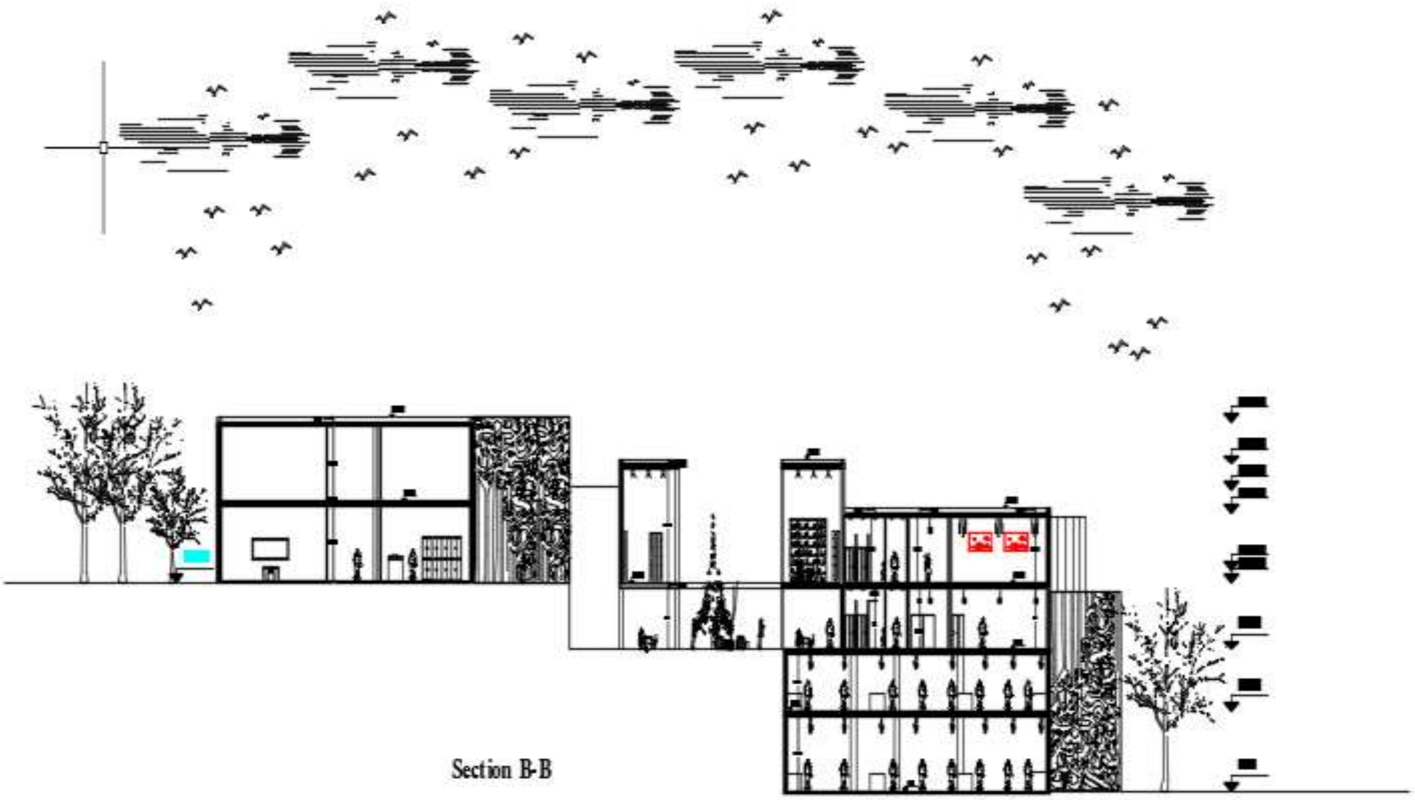


Figure (2.12): Section B-B

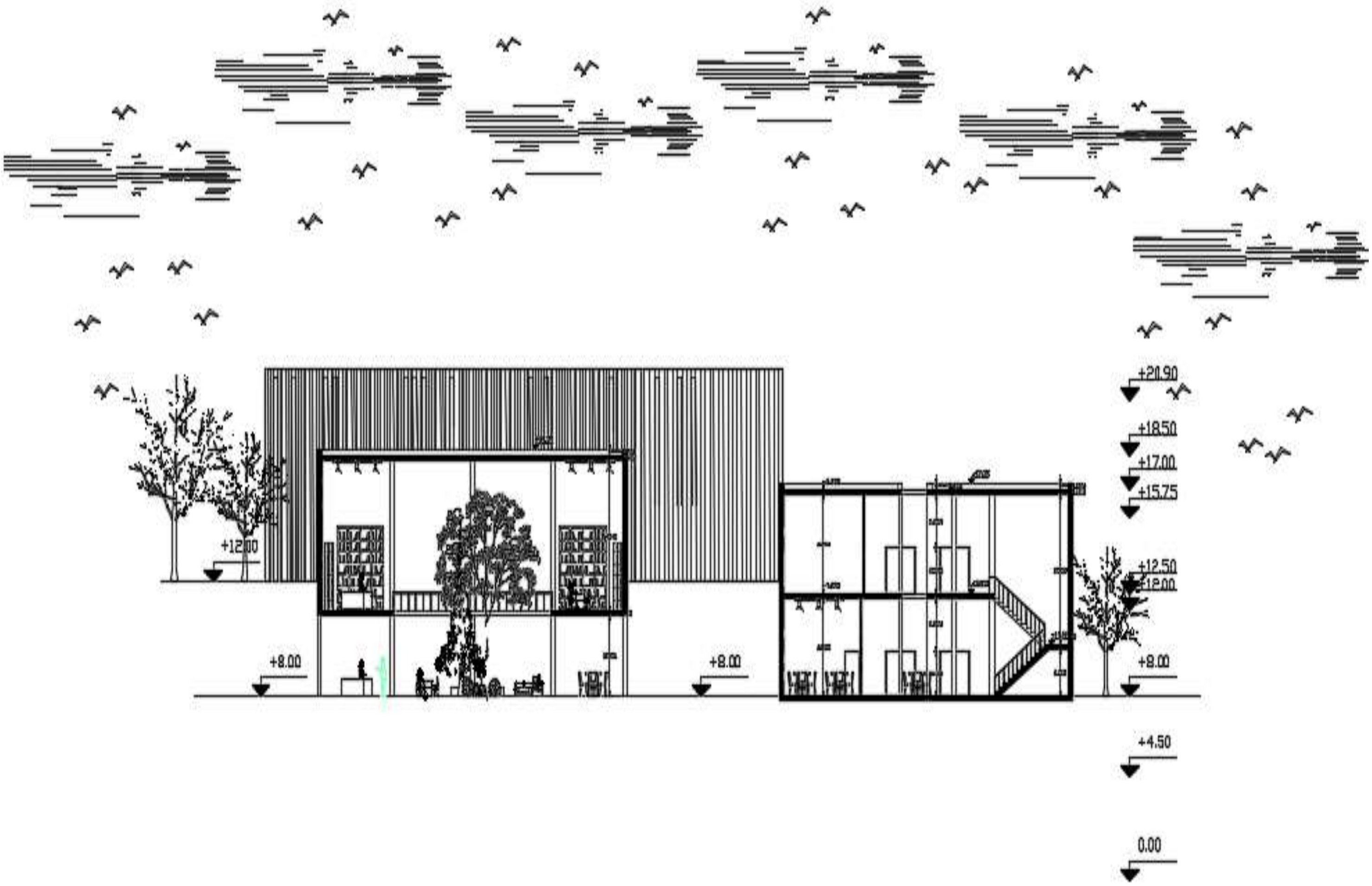


Figure (2.13): Section A-A

Chapter 3

Structural Description

Structural Description

3.6.5 Foundation

3.6.6 Stairs

3.6.7 Expansion joint

3.1 Introduction

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

3.2 The goal of the structural design

The structural design is an integrated and balanced structural system, it meets the established requirements and desires of users, and thus determines the structural elements from the following:

- Factor of Safety: Is achieved by selecting structural elements capable of withstanding the forces and resulting stresses.
- Economy: Check by choosing the appropriate building materials and by choosing the perfect low-cost section.
- Serviceability: To avoid excessive landing (deflection), fissures (cracks).
- Preservation of architectural design.
- Preserving the environment.

3.3 Scientific tests

Before the design of any construction project must be doing some tests, tests of the soil to see breaking strength, specifications, type, the underground water level and depth of the foundation layer.

3.4 Stages of structural design

We will distribute the structural design of the project in two phases:

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

3.5 Loads acting on the building.

There are a number of different types of loads that can act upon a structure, the nature of which will vary according to design, location, and so on. Design requirements are generally specified in terms of the maximum loads that a structure must be able to withstand.

Loads are generally classified as either dead loads (DL) or live loads (LL)

3.5.1 Dead loads

Dead load includes loads that are relatively constant over time, including the weight of the structure itself, and immovable fixtures such as walls, plasterboard or carpet. Roof is also a dead load. Dead loads are also known as permanent loads.

Designer can also be relatively sure of the magnitude of dead loads as they are closely linked to density and quantity of the construction materials. These have a low variance, and the designer is normally responsible for specifying these components

Figure (3.1): Dead Loads

3.5.2 Live loads

Live load is imposed loads which are temporary, of short duration, or moving. These dynamic loads may involve consideration such as impact, momentum, vibration, slosh dynamic of fluids, fatigue, etc. Live loads, sometimes also referred to as probabilistic loads include all the forces that are variable within the object's normal operation cycle not including construction or environmental loads.

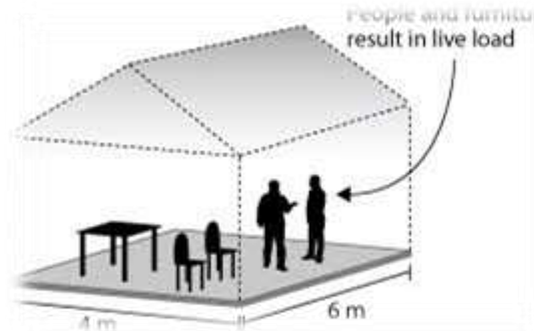


Figure (3.2): Live Loads

3.5.3 Snow loads

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

The following table shows the relationship between the height of the building and carry snow

that we take him in the case of design.

Figure (3.3): Snow Loads

3.5.4 Earthquake loads

Loads caused by earthquakes. Buildings should be designed to withstand minor earthquakes because they can occur almost anywhere. During an earthquake the ground can move both horizontal and vertically in any direction. This exerts tremendous horizontal loads on members.

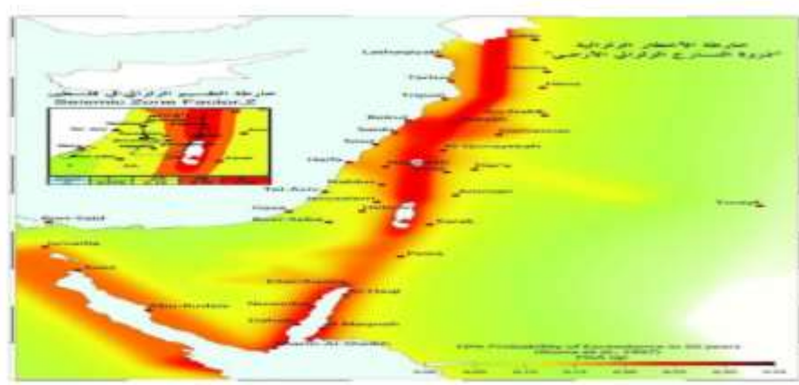


Figure (3.4): Earthquake Loads

3.5.5 Wind loads

The forces that affect horizontally on the building appear especially in high-rise buildings, and its de- signed on the basis of wind speed and height of the building, and the amount of buildings surrounding the building.

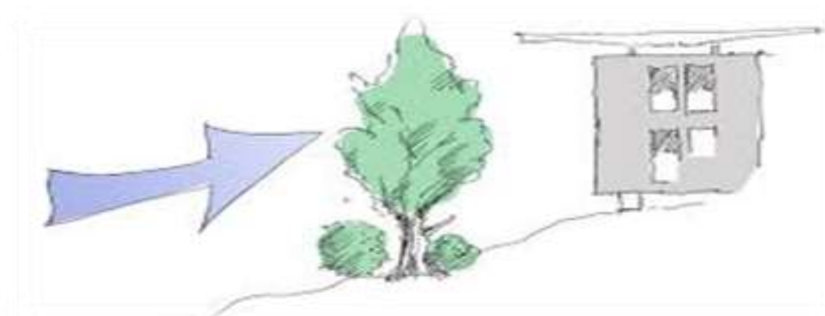


Figure (3.5): Wind Loads

3.6 Structural elements of the building.

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

3.6.1 Slabs

Structural elements are capable of delivering vertical forces due to the loads affecting the building's load-bearing structural elements such as beams, columns and walls. And In our project, we will use different types including:

3.6.1.1 Rib Slab

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

- **One-way ribbed slab.**
- **Two-way ribbed slab.**

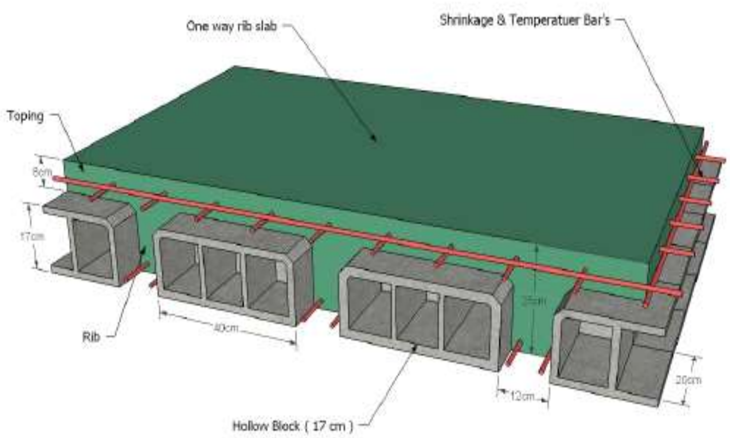


Figure (3.6): One Way ribbed Slab

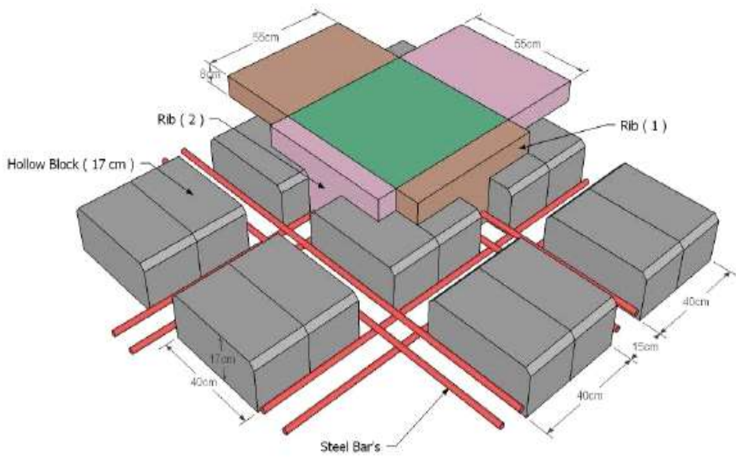


Figure (3.7): Two Way ribbed Slab

3.6.1.2 Solid Slab

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

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

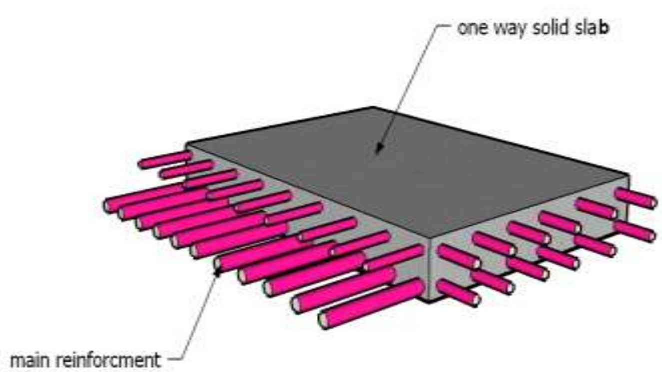


Figure (3.8): One Way solid Slab

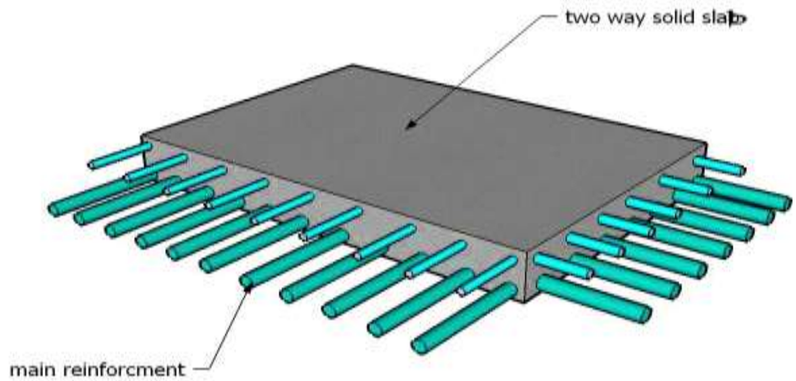


Figure (3.9): Two Way solid Slab

3.6.2 Beams

The basic structural elements in moving load of tiles into columns, and they are of two types:

- Hidden Beam: Hidden inside Slabs.
- Dropped Beam: (Paneled)

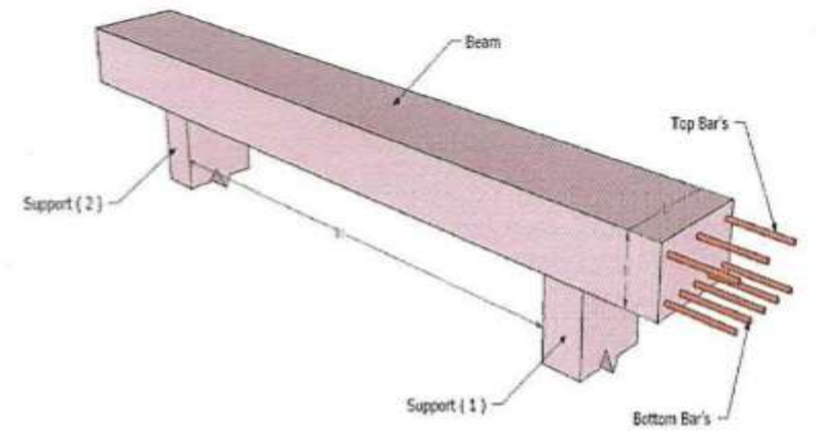


Figure (3.10): Hidden Beams

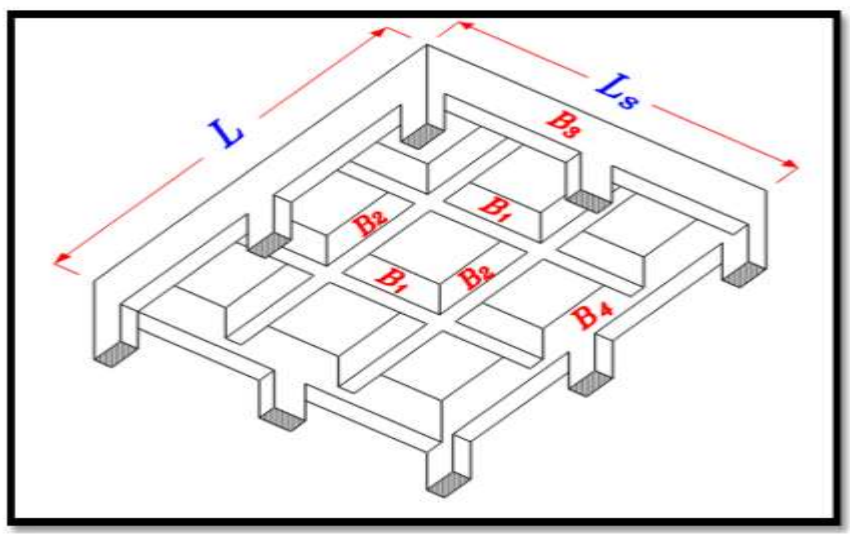


Figure (3.11): Dropped Beams

3.6.3 Columns

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

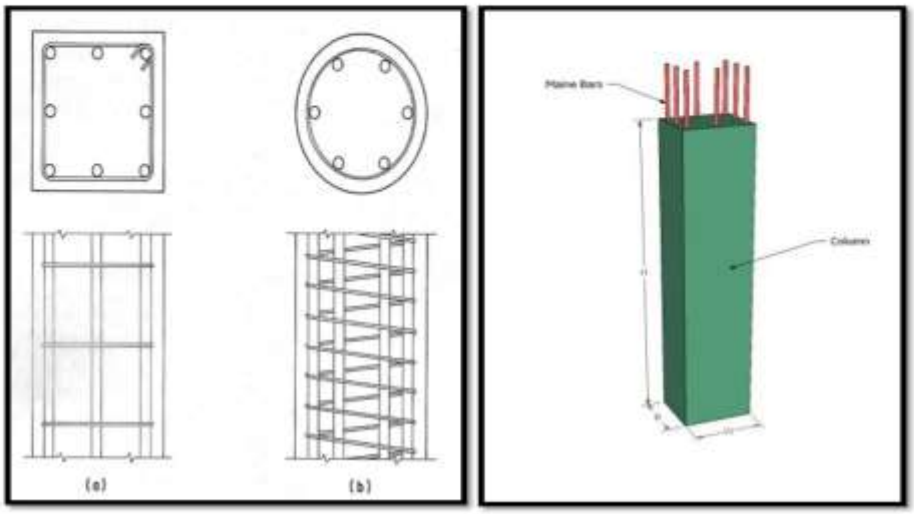


Figure (3.12): columns

3.6.4 Shear wall

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

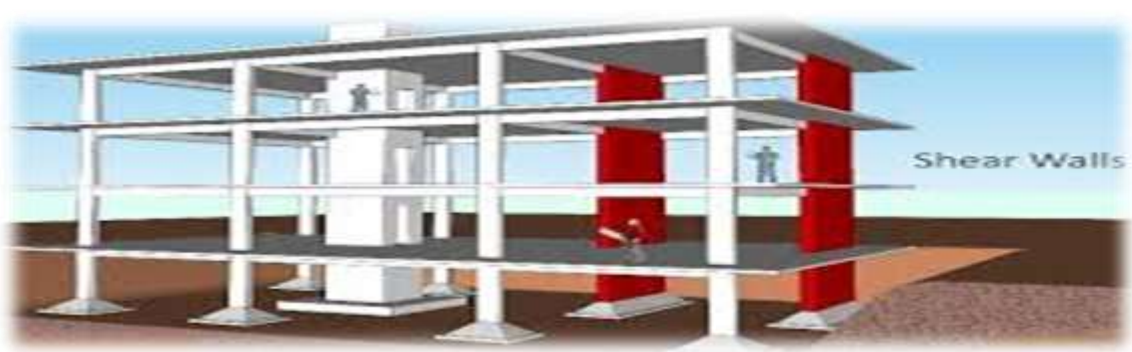


Figure (3.13): Shear Walls

3.6.5 Foundation

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

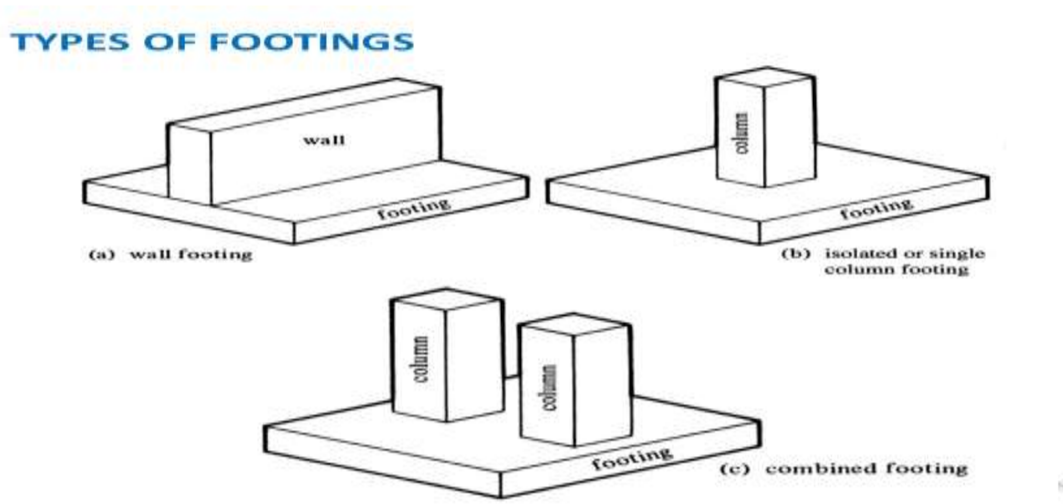


Figure (3.14): Types Of Foundations.

3.6.6 Stairs

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

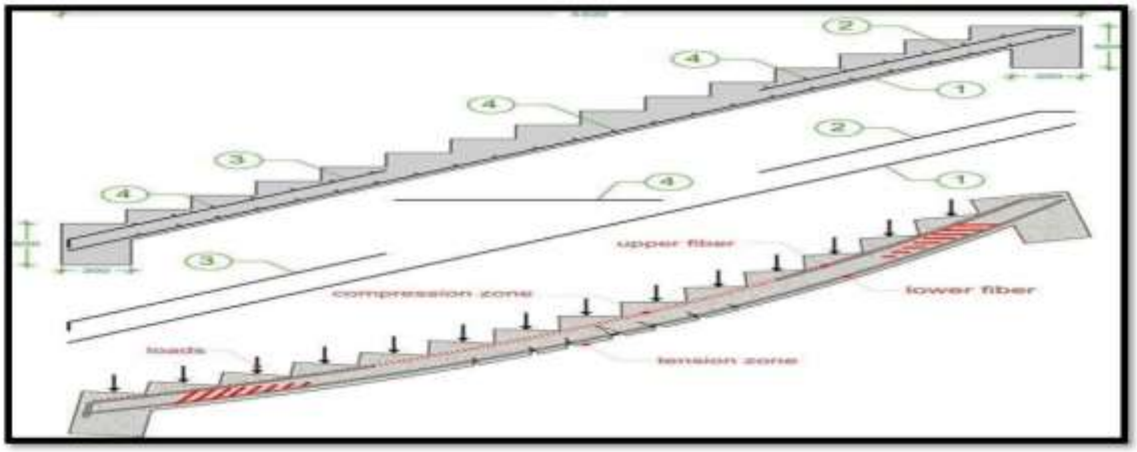


Figure (3.15): Stairs.

3.6.7 Expansion joint

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

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

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

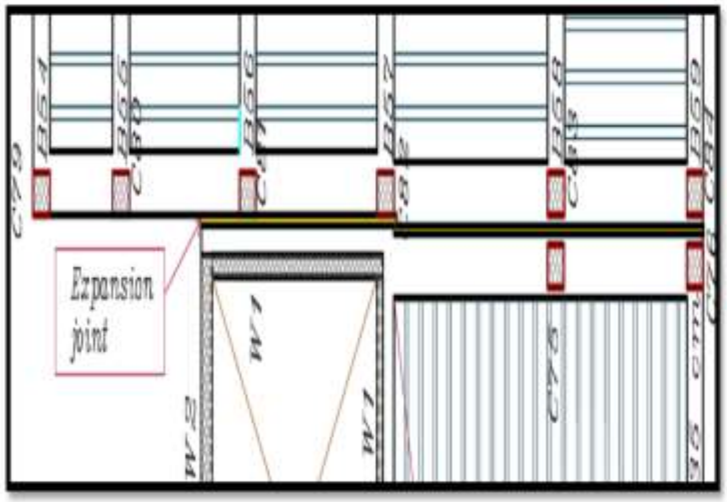


Figure (3.16): Expansion Joints.

Chapter 4

Design of structural members

Design of structural members

4.1 Introduction.

This chapter contains the structural analysis and design of some elements of Halhul Arabic Language Complex.

The structural design of the project is the most important thing to be done, through design we determine the amount of reinforcement in each part of the project to be realized all the conditions of construction and safety.

As we mentioned before, ACI 318m-11, and some engineering program were used in the design of the structures like: Atir, spColumn, Etabs and Safe to find the internal forces, deflection and moments, and then hand calculation were done to find the required reinforcement for the structures.

4.2 Factored loads.

The factored loads on which the structural analysis and design is based for structural members, is

determined as follows:

qu = 1.2DL + 1.6L.L,   ACI – 318 – 11

4.3 Determination of thickness

4.3.1 Determination of thickness for one-way ribbed slab.

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 overall depth must satisfy ACI Table (9.5.a):

The maximum span for one –end continuous (for ribs) is: L= 5821mm

h min= $\frac{L}{18.5} = \frac{5821}{18.5}$ **=314.6mm**

The maximum span for two - end continuous (for ribs) is: L= 5821m mm

h min= $\frac{L}{21} = \frac{5821}{21}$ **= 277.2 mm**

The minimum ribbed slab thickness will be h min =314.6 mm

The slab thickness h= 320mm >h min =314.6mm

h=32cm (24cm hollow block + 8cm topping)

4.3.2 Load calculations

One-way ribbed slab.

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

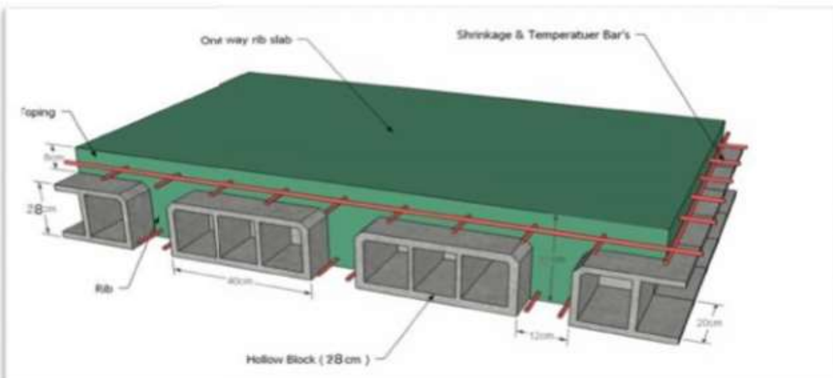


Figure (4.1): One-way ribbed slab.

Calculation of the total dead load for one-way rib slab is shown in the following table:

No.	Dead load from:	Density (KN/m)	Calculations	KN/m
1	Tiles	23	0.03*23*0.52=	0.359
2	Mortar	22	0.03*22*0.52=	0.343
3	Sand	17	0.07*17*0.52=	0.619
4	Topping	25	0.08*25*0.52=	1.04
5	Rib	25	0.24*25*0.12=	0.72
6	Block	10	0.24*10*0.4=	0.96
7	Plaster	22	0.03*22*0.52=	0.343
8	Partitions		2.3*0.52=	1.196
				5.58

Table (4.1): calculation of total load of One-way ribbed slab

Dead Load /rib :DL =5.58KN /m.

Live Load /rib :LL = 5 * 0.52= 2.6KN/m.

4.4 Design of one-way ribbed slab.

4.4.1 Design of topping

No.	Dead load from	Density (KN/m)	Calculations	KN/m
1	Tiles	23	0.03*23=	0.96
2	Mortar	22	0.03*22=	0.66
3	Sand	17	0.07*17=	1.19
4	Topping	25	0.08*25=	2
5	Partitions		2.3*1=	2.3
				7.11

Table (4.2): calculation of total load of topping of slab

(Assume a stripe 1 m long with 0.4 m width).

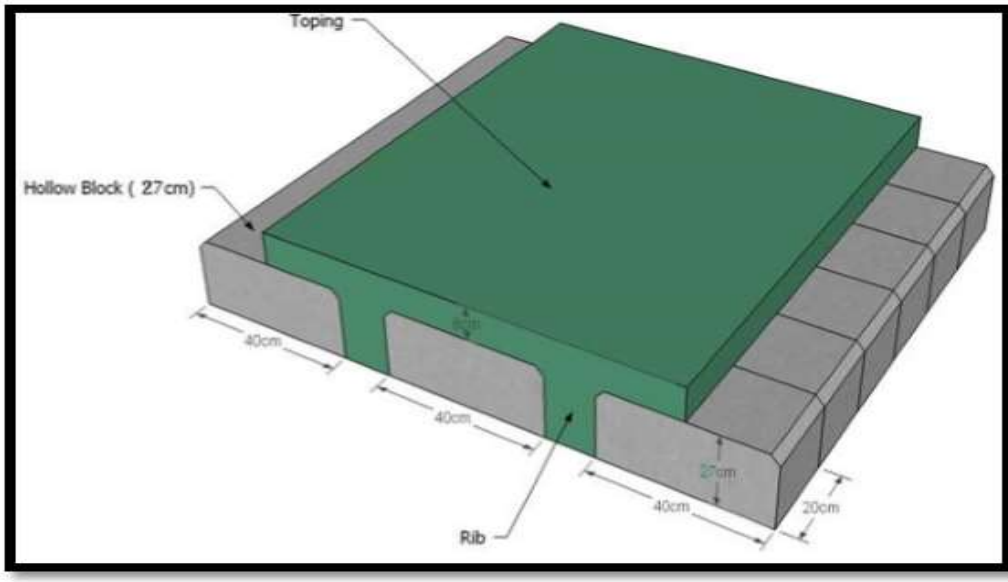


Figure (4.2): Topping of slab.

W u = 1.2×DL+1.6×LL
= 1.2×5.58+1.6×5 = 14.696 KN/m.

(Total Factored Load). Assume slab fixed at supported points (ribs):

Mu= $\frac{Wu*l^2}{12}$ =$\frac{14.696*0.4^2}{12}$ = 0.196 KN.m

$\emptyset Mn \geq Mu$ (strength condition), where $\emptyset = 0.55$(for plain concrete)

Mn = 0.42μ$\sqrt{fc}$ Sm (ACI 22.5.1, equ 22-2)

Where Sm for rectangular section for the slab:

Sm= $\frac{bh^2}{6}$ =$\frac{1000*80^2}{6}$ = 1066666.67 mm^3

$\emptyset Mn$= 0.55* 0.42μ$\sqrt{24}$* 1066666.67*10^{-6} =2.19 KN.m

$\emptyset Mn = 2.19 \text{KN.m} \gg \text{Mu} = 0.196 \text{KN.m}$

No structural reinforcement needed. Therefore, shrinkage and temperature reinforcement must provide.

For the shrinkage and temperature reinforcement:

ρ min=0.0018 As= ρ*b*h=0.0018*1000*80=144mm^2/m strip.

Try bars Ø8 with As =50.27mm^2

Bar numbers n= $\frac{As}{As\ \emptyset 8}$ =$\frac{144}{50.27}$ = 2.87

Take 3Ø8 with As = 150.8 mm^2/m strip or Ø8@ 300mm in both directions.

Step (s) is the smallest of:

1. 3h = 3*80= 240mm. (control)
2. 450mm
3. S= 380 ($\frac{280}{fs}$) -2.5 Cc = 380 ($\frac{280}{\frac{2}{3}420}$) -2.5 *20= 340 mm but

   s≤ $300(\frac{280}{fs})$ = 300 ($\frac{280}{\frac{2}{3}420}$) = 315mm.

   Take Ø8@200mm in both directions. S=200mm $< s\ max = 240mm.$ (Ok)

4.4.2 Design of rib R-26

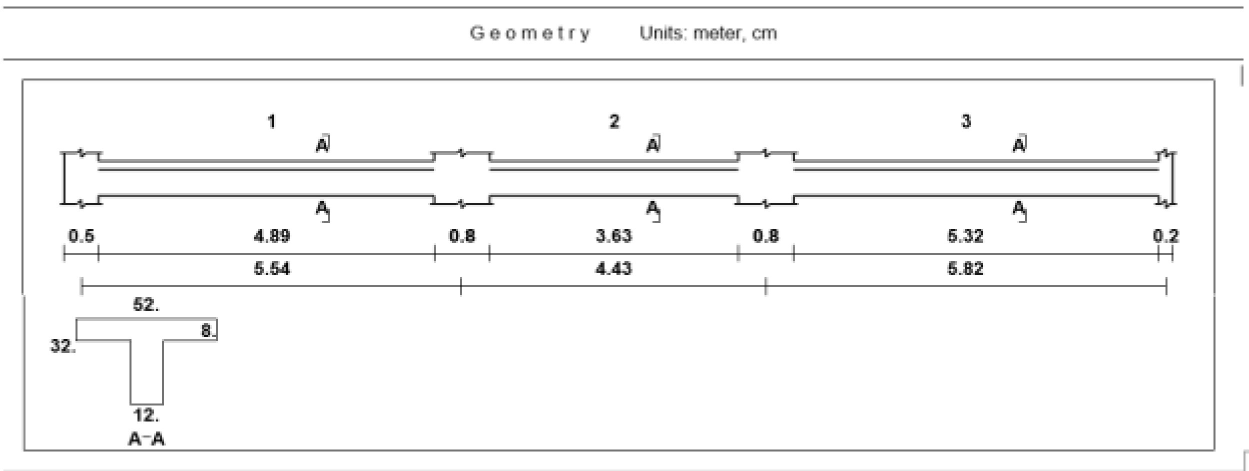


Figure (4.3): Geometry of rib 1.

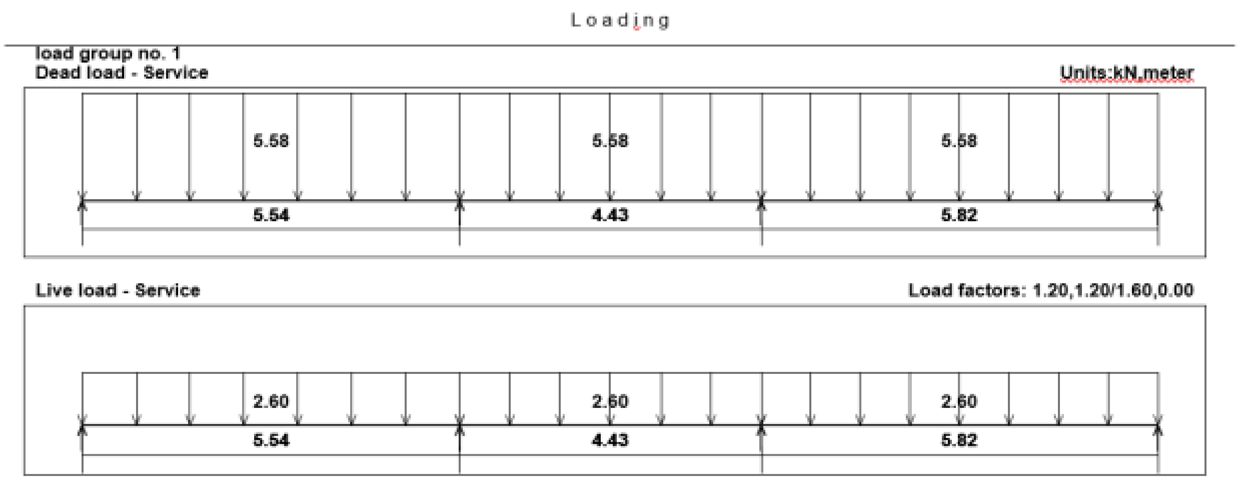
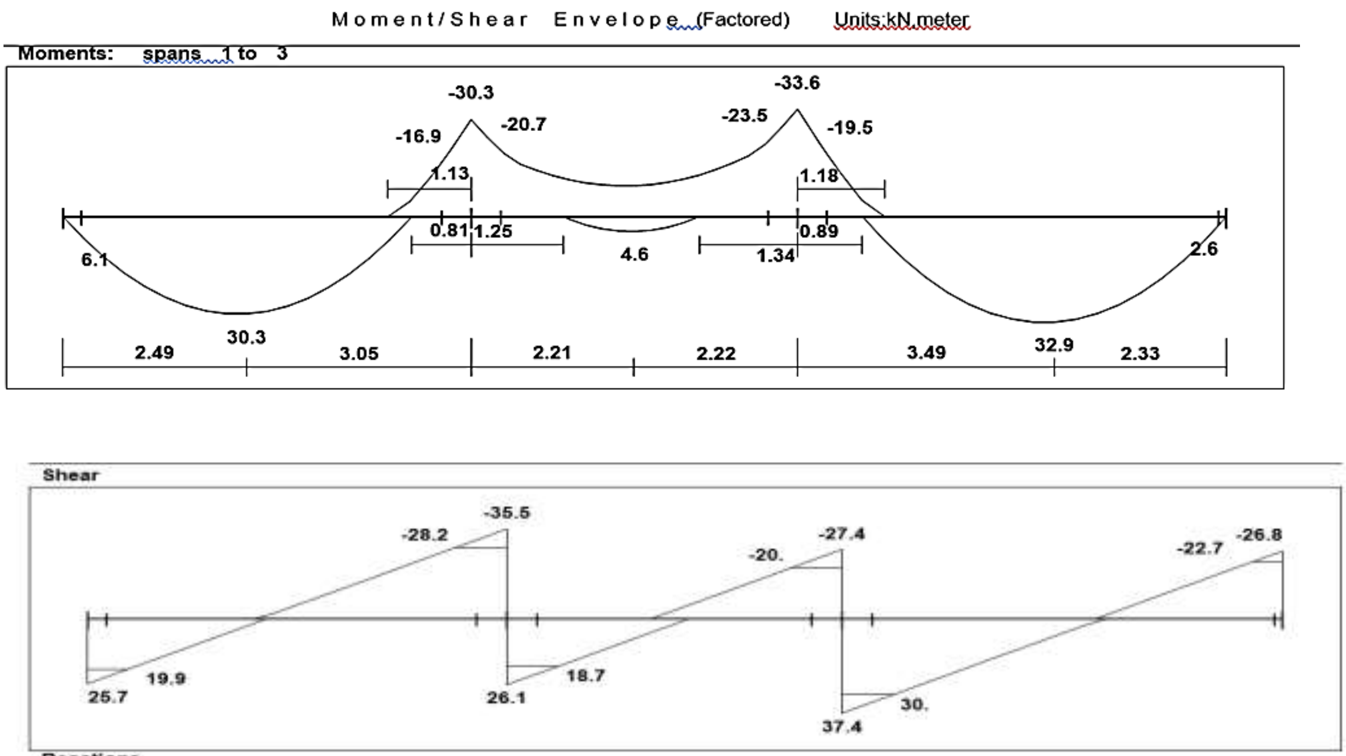


Figure (4.4): loads of rib 1.



Reactions

Factored				
DeadR	15.43	35.99	38.16	16.14
LiveR	10.26	25.68	26.61	10.65
MaxR	25.7	61.67	64.78	26.79
MinR	14.76	42.59	45.07	15.52
Service				
DeadR	12.86	29.99	31.8	13.45
LiveR	6.41	16.05	16.63	6.65
MaxR	19.28	46.04	48.44	20.1
MinR	12.44	34.12	36.12	13.06

Figure (4.5): Moment & shear envelopes of rib 1.

4.4.2.1 Design of positive moments for R-26

Effective Flange width (be), ACI-318-11

(be) For T- section is the smallest of the following:

- be$\leq \frac{L}{4} = \frac{2410}{4} =$ 602.5 mm
- be$\leq$ bw +16 hf = 120+ 16 *80= 1400mm
- be $\leq$ center to center spacing of beams =520mm (control)

Take be = 520mm

Assume bar diameter Ø12 for main positive reinforcement.
d= h - cover- d stirrups - $\frac{db}{2}$ = 320 -20 -8 - $\frac{12}{2}$ =286mm

- ((Mu max = +32.9 KN.m))

Check if a>hf
Mnf =0.85fc b hf (d-$\frac{hf}{2}$) = 0.85 *24*520 *80(286 -$\frac{80}{2}$) * 10^{-6}= 217.46 KN.m
Mnf= 217.46 KN.m $\gg \frac{Mu}{\emptyset} = \frac{32.9}{0.9}$ = 36.56 KN.m……… so (a$< hf$)

The section will be designed as rectangular section with b =520mm

Rn= $\frac{Mu}{\emptyset b d^2} = \frac{32.9 * 10^6}{0.9*520*286^2} =$ 0.86 Mpa

m = $\frac{fy}{0.85\ fc} = \frac{420}{0.85*24}$ = 18.82

$\rho = \frac{1}{m}(1-\sqrt{1-\frac{2Rnm}{fy}}) = \frac{1}{18.82}(1-\sqrt{1-\frac{2*0.86*18.82}{400}}) = 0.002$

As = ρ bd = 0.002* 520*286 = 297.44mm^2

Check for As, min:
As, min = 0.25 $\frac{\sqrt{fc}}{fy}$ bw d $\geq \frac{1.4}{fy}$ bw d

As, min = 0.25 $\frac{\sqrt{24}}{420}$ 120*286 = 107.25 mm^2
As, min = $\frac{1.4}{420}$ 120*286= 120.12 mm^2 (control)

As= 297.44 mm^2 >As, min = 120.12 mm^2 (ok)
Use 2Ø14 with As= 3.079cm^2 > As, req= 2.97cm^2
Check for strain:
a = $\frac{As\ fy}{0.85\ fc\ b}$ = $\frac{308*420}{0.85*24*520}$ = 11.15 mm, $\beta = 0.85$

c= $\frac{a}{\beta}$ = $\frac{11.15}{0.85}$= 13.12 mm

$\epsilon s = 0.003 \left(\frac{d-c}{c}\right)$ = 0.003 ($\frac{286-13.12}{13.12}$) = 0.062> 0.005 (ok)

4.4.2.2 Design of negative moments for R26

Assume bar diameter Ø12 for main negative reinforcement.
d= h - cover- d stirrups - $\frac{db}{2}$ = 320 -20 -8 - $\frac{12}{2}$ =286 mm

- ((Mu max = -23. 5 KN.m))

Rn= $\frac{Mu}{\emptyset b d^2}$ = $\frac{23.5*10^6}{0.9*120*286^2}$ = 2.66 Mpa

m = $\frac{fy}{0.85\ fc}$ = $\frac{420}{0.85*24}$ = 18.82

$\rho = \frac{1}{m}$ (1-$\sqrt{1-\frac{2Rnm}{fy}}$) = $\frac{1}{18.82}$ (1-$\sqrt{1-\frac{2*2.66*18.82}{420}}$) = 0.0071

As = ρ bw d = 0.0071* 120*286= 243.67 mm^2

Check for As, min:
As, min = 0.25 $\frac{\sqrt{fc}}{fy}$ bw d ≥ $\frac{1.4}{fy}$ bw d

As, min = 0.25 $\frac{\sqrt{24}}{420}$ 120*286 = 107.25 mm^2

As, min = $\frac{1.4}{420}$ 120*286= 120.12 mm^2 (control)

As=243.67mm^2 >As, min = 120.12 mm^2 (ok)
Use 2Ø14 with As= 3.079cm^2 > As, req= 2.43cm^2

Check for strain:
a = $\frac{As\ fy}{0.85\ fc\ b}$ = $\frac{308*420}{0.85*24*120}$ = 48.31 mm, $\beta = 0.85$

c= $\frac{a}{\beta}$ = $\frac{48.31}{0.85}$= 56.84 mm
$\epsilon s = 0.003\left(\frac{d-c}{c}\right) = 0.003\ (\frac{286-56.84}{56.84}) = 0.012 > 0.005$ (ok)

4.4.2.3 Design of shear for R-26

Vu= 30 KN
Vc= (1.1) *$\frac{1}{6}$ μ$\sqrt{fc}$ bw d = (1.1) * $\frac{1}{6}$*1*$\sqrt{24}$*120*286*10^{-3} = 31.46 KN

$ØVc = 0.75 * 31.46 = 23.6\ KN$

Vs, min= $\frac{1}{16}$ $\sqrt{fc}$ bw d = $\frac{1}{16}$ $\sqrt{24}$ *120 *286 *10^{-3} =10.725 KN

Vs, min = $\frac{1}{3}$ bw d = $\frac{1}{3}$ *120*286*10^{-3} = 11.44 KN (control)

$Ø\text{Vs}, \min = 0.75 * 11.44 = 8.58$ KN

Region (3)

$(ØVc = 23.595KN < Vu = 30KN \leq$ (ØVc+ $Ø * Vs, min$) =32.18 kN (ok)

$ØVs = Ø * Vs, min$ = 8.58 KN

ØVs = Ø $\frac{Av}{s}$ * fy*d

Av= 2$\frac{\pi}{4}$*8^2= 100.5 mm^2

S=$\frac{Av*fy*d}{Vs}$ = $\frac{0.75*100.5*420*263}{8.58*10^3}$ = 924.18 mm

But

s≤ $\frac{d}{2}$= $\frac{263}{2}$ =131.5 mm (control)

s≤ $600mm$

take s= 131.5mm

4.4.3 Design of beam 67

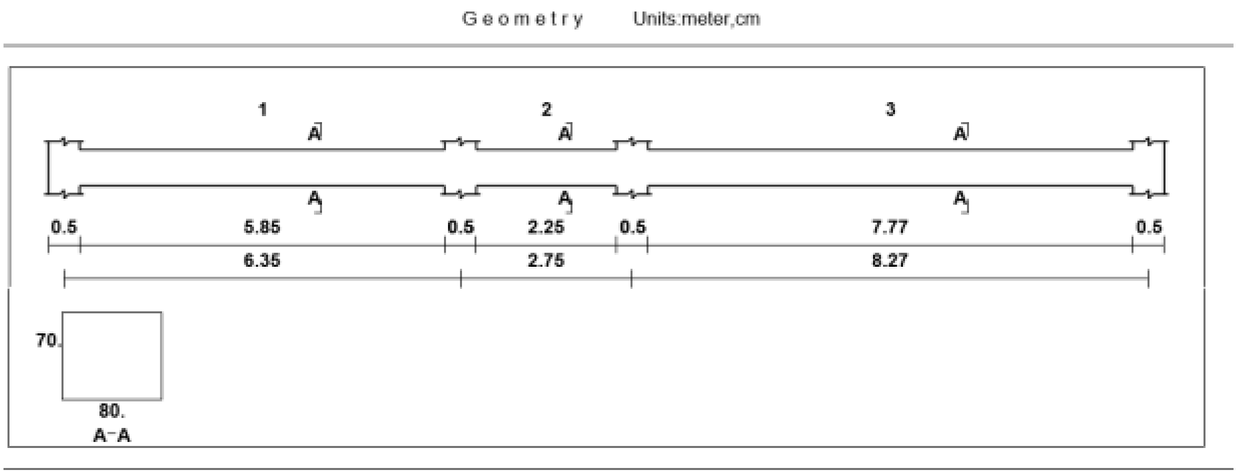


Figure (4.6): Geometry of beam 2.

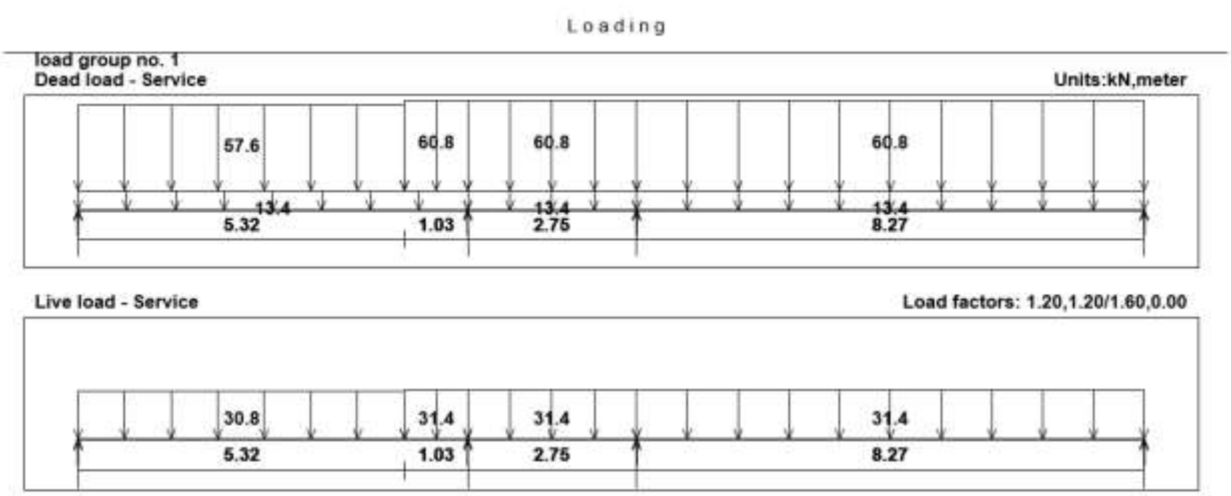
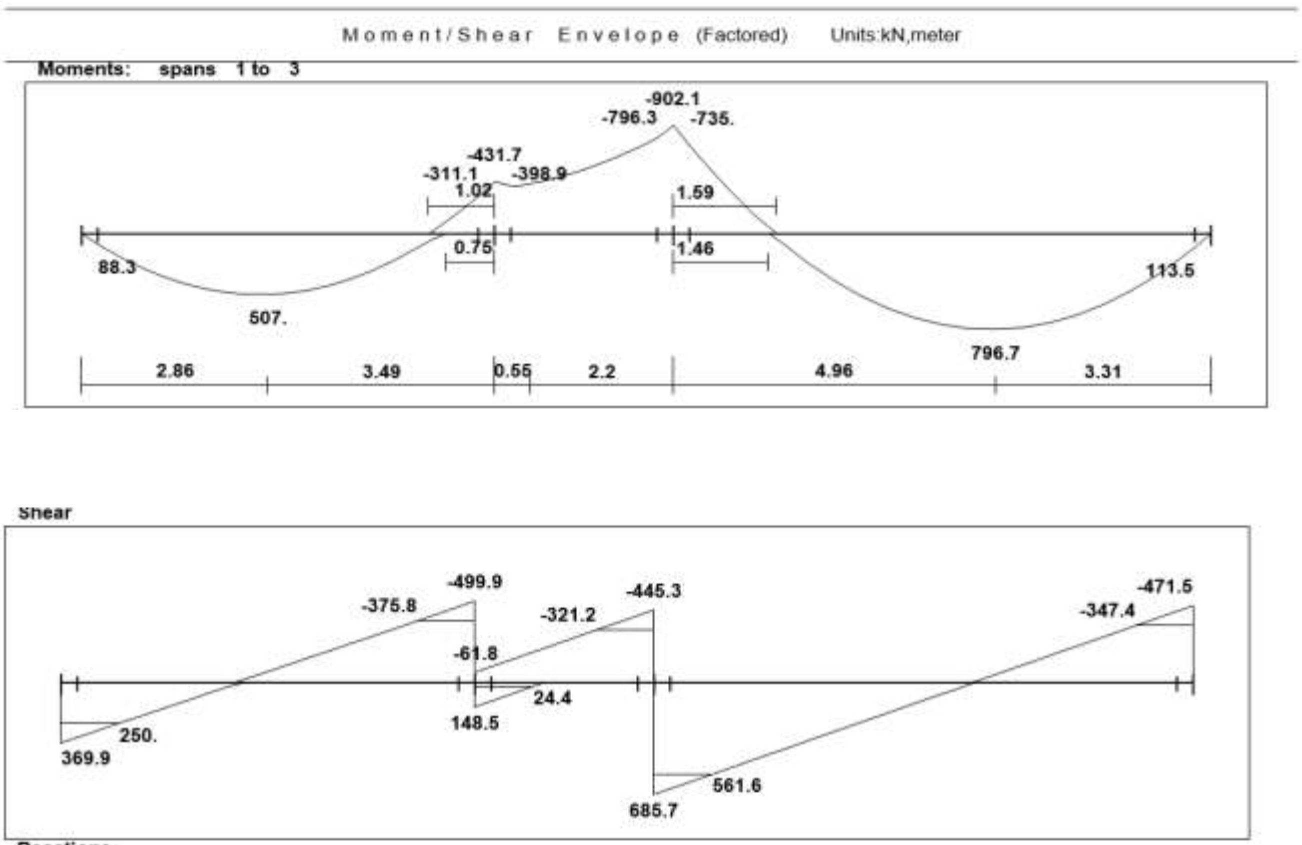


Figure (4.7): loads of beam 2.



Reactions

Factored				
DeadR	233.15	318.22	675.53	300.37
LiveR	136.75	330.19	455.53	171.12
MaxR	369.91	648.41	1131.06	471.49
MinR	231.13	244.72	669.94	299.13
Service				
DeadR	194.29	265.18	562.94	250.31
LiveR	85.47	206.37	284.71	106.95
MaxR	279.77	471.55	847.65	357.26
MinR	193.03	219.25	559.44	249.53

Figure (4.8): Moment & shear envelopes of beam 2.

4.4.3.1 Design of positive moments for B-67

Assume bar diameter Ø18 for main positive reinforcement.

d= h - cover- d stirrups - $\frac{db}{2}$ = 700 -40 -8 - $\frac{18}{2}$ =643 mm

((Mu max = +796.7 KN.m))

C = $\frac{3}{7}$ d = $\frac{3}{7}$ *643= 275.6 mm

a = β *c = 0.85* 275.6 = 234.2 mm

Mn, max = 0.85 fc a b (d - $\frac{a}{2}$) = 0.85* 24*234.2*800*(643 -$\frac{234.2}{2}$) *10^{-6}= 2093.8 KN.m

$\emptyset = 0.82$

Mu= 796.7 KN.m $< \emptyset Mn =$ 0.82* 2093.8 = 1717 KN

Design the section as singly reinforced concrete section.

Rn= $\frac{Mu}{\emptyset b d^2}$ = $\frac{796.7 * 10^6}{0.9 * 800 * 643^2}$ = 2.67 Mpa

m = $\frac{fy}{0.85\ fc}$ = $\frac{420}{0.85 * 24}$ = 18.82

ρ = $\frac{1}{m}$ (1-$\sqrt{1-\frac{2Rnm}{fy}}$) = $\frac{1}{18.82}$ (1-$\sqrt{1-\frac{2*2.67*18.82}{420}}$) =0.0072

As = ρ bd = 0.0072* 800*643 = 3703.68 mm^2

Check for As, min:

As, min = 0.25 $\frac{\sqrt{fc}}{fy}$ bw d ≥ $\frac{1.4}{fy}$ bw d

As, min = 0.25 $\frac{\sqrt{24}}{420}$ 800*643 = 1607.5 mm^2

As, min = $\frac{1.4}{420}$ 800*643= 1800.4 mm^2 (control)

As= 3703.68 mm^2 >As, min = 1800.4 mm^2 (ok)

Use $6\emptyset 20 + 7\emptyset 20$ with As= 40.8 cm^2 $>$ As, req= 37.03cm^2

Check for strain:

a = $\frac{As\ fy}{0.85\ fc\ b}$ = $\frac{408*420}{0.85*24*800}$ = 9.6 mm, β = 0.85

c= $\frac{a}{\beta}$ = $\frac{9.6}{0.85}$= 11.3mm

ϵs = 0.003 $\left(\frac{d-c}{c}\right)$ = 0.003 ($\frac{643-11.3}{11.3}$) = 0.16> 0.005 (ok)

4.4.3.2 Design of negative moment for B-67

Assume bar diameter Ø18 for main positive reinforcement.

d= h - cover- d stirrups - $\frac{db}{2}$ = 700 -40 -8 - $\frac{18}{2}$ = 643 mm

((Mu max = -796. 3KN.m))

C = $\frac{3}{7}$ d = $\frac{3}{7}$ *643= 275.6 mm

a = β *c = 0.85* 275.6 = 234.2 mm

Mn, max = 0.85 fc a b (d - $\frac{a}{2}$) = 0.85* 24*234.2*800*(643 -$\frac{234.2}{2}$) *10^{-6}= 2093.8 KN.m

Ø = 0.82

Mu= 796.3 KN.m < $\emptyset Mn$ = 0.82* 2093.8 = 1717 KN

Design the section as singly reinforced concrete section.

Rn= $\frac{Mu}{\emptyset b d^2}$ = $\frac{796.3*10^6}{0.9*800*643^2}$ = 2.67Mpa

m = $\frac{fy}{0.85\ fc}$ = $\frac{420}{o.85*24}$ = 18.82

$\rho = \frac{1}{m}$ (1-$\sqrt{1-\frac{2Rnm}{fy}}$) = $\frac{1}{18.82}$ (1-$\sqrt{1-\frac{2*2.67*18.82}{420}}$) =0.0072

As = ρ bd = 0.0072* 800*643 = 3703.68 mm^2

Check for As, min:

As, min = 0.25 $\frac{\sqrt{fc}}{fy}$ bw d ≥ $\frac{1.4}{fy}$ bw d

As, min = 0.25 $\frac{\sqrt{24}}{420}$ 800*643 = 1607.5 mm^2

As, min = $\frac{1.4}{420}$ 800*643= 1800.4 mm^2 (control)

As= 3703.68 mm^2 >As, min = 1800.4 mm^2 (ok)
Use $6\emptyset 20 + 7\emptyset 20$ with As= 40.8 cm^2 > As, req= 37.03cm^2

Check for strain:
a = $\frac{As\ fy}{0.85\ fc\ b}$ = $\frac{408*420}{0.85*24*800}$ = 9.6 mm, $\beta = 0.85$

c= $\frac{a}{\beta}$ = $\frac{9.6}{0.85}$= 11.3mm
$\epsilon s = 0.003 \left(\frac{d-c}{c}\right)$ = 0.003 $(\frac{643-11.3}{11.3})$ = 0.16> 0.005 (ok)

4.4.3.3 Design of shear for B-67

Vu max= 561.6 KN

Vc= $\frac{1}{6}$ μ$\sqrt{fc}$ bw d = $\frac{1}{6}$*1*$\sqrt{24}$*800*263*10^{-3} = 175.33 KN

$\emptyset Vc = 0.75 * 175.33 = 131.5\ KN$

Vs, min= $\frac{1}{16}$ $\sqrt{fc}$ bw d = $\frac{1}{16}$ $\sqrt{24}$ *800 *263 *10^{-3} = 65.75KN

Vs, min = $\frac{1}{3}$ bw d = $\frac{1}{3}$ *800*263*10^{-3} = 70.133 KN (control)

$\emptyset Vs, min = 0.75 * 70.133 = 52.6$ KN

$\emptyset$(Vc+ $\frac{1}{3}$ $\sqrt{24} * 800 * 263$)=394.5 KN

$\emptyset$(Vc+ $\frac{2}{3}$ $\sqrt{24} * 800 * 263$)=657.5 KN

Region (5)

$\emptyset$(Vc+ $\frac{1}{3}$ $\sqrt{24} * 800 * 263$) < Vu= 561.6 KN ≤ $\emptyset$(Vc+ $\frac{2}{3}$ $\sqrt{24} * 800 * 263$)

$Vs = \frac{Vu - \emptyset Vc}{\emptyset}$ = $\frac{561.6 - 131.5}{0.75}$ = 573.5KN

$Vs = \frac{Av}{s} * fy*d$

$Av = 2\frac{\pi}{4}*8^2 = 100.5\ mm^2$

$S = \frac{Av*fy*d}{Vs} = \frac{100.5*420*263}{573.5*10^3} = 18.43$ mm

But

$s \le \frac{d}{4} = \frac{263}{4} = 65.75$ mm (control)

$s \le 600mm$

take s= 18.43mm

4.5Design of Column (7)(Group F1):

Material: -

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

Load Calculation: -

Service Load: -

Dead Load = 500KN
Live Load = 200 KN

Factored Load: -

P_U = 1.2 ×500+ 1.6×200= 920KN

✓ Dimensions of Column: -

$$Assume\rho g = 0.01$$

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

$$920 = 0.65 \text{ x } 0.8 \times \text{Ag} \{0.85 * 24 (1 - 0.01) + 0.01 * 420\}$$

Ag=102.115 cm2

Use dimension 400*400 with Ag = 160 cm2 > Ag required

1) $Check\ for\ Slenderness$:

$$\frac{K \times l_u}{r} \leq 34 - 12\left(\frac{M_1}{M_2}\right) \leq 40$$

$(= 1 - for\ braced\ frame\ with\ M_{min}.\ \frac{M_1}{M_2})$

l_u: Actual unsupported (unbraced) length.

r: radius of gyration of its cross section $= 0.3\ h$

$l_u = 3.75\ m$

$K = 1.0 - for\ columns\ in\ nonsway\ frame.$

About axis-X

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

$$\frac{1*3.75}{0.3*0.4} = 31.25 > 22$$

Column Is Long About X-axis

- about Y-axis

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

$$\frac{1*3.75}{0.3*0.4} = 31.25 > 22$$

Column Is long About Y-axis

2) *Calculate the minimum eccentricity* $_{min}e$ *and the minimum moment*:

$$_{min}e = 15 + 0.03 \times h = 15 + 0.03 \times 400 = 27\ mm$$

$$_{u}P \quad = 984.54\ KN$$

$$_{min}M = {_u}P \times {_{min}}e = 984.54 * .027 = 26.58\ KN.m$$

3) *Compute EI*:

$$EI = 0.4\frac{E_c I_g}{1+\beta_d}$$

$$E_c = 4750\sqrt{fc'} = 4700 \times \sqrt{24} = 23270.2Mpa$$

$$\beta_d = \frac{1.2DL}{Pu} = \frac{1.2*(500)}{984.54} = 0.61 < 1$$

$$I_g = \frac{b \times h^3}{12} = \frac{400 \times 400^3}{12} = 2.13*10^9 mm^4$$

$$EI = \frac{0.4 \times 23270.2 \times 9}{1+0.61} = 12314.4KN.m^2$$

4) *Determine the Euler buckling load*, $_{c}P$:

$$P_C = \frac{\pi^2 * 12314.4}{(1*3.75)^2} = 8642.7KN$$

5) *Calculate the moment magnifier factor* $_{ns}\delta$:

$$C_m = 0.6 + 0.4 \times \frac{M_1}{M_2} = 0.6 + 0.4 \times 1 = 1.0$$

$$\delta_{ns} = \frac{1}{1 - \frac{984.54}{0.75 * 8642.7}} = 1.18 \geq 1 and \leq 1.4 OK$$

:ntmome and eccentricity magnifid ehT →

$$e = e\min * \delta ns = 27 * 1.18 = 31.86$$

$$Mc = \delta ns * M2 = 1.18 * 26.58 = 31.36 KN.m$$

$$where (M2 = M\min = Pu * e\min = 984.54 * 27 = 26.58)$$

$$\frac{e}{h} = \frac{31.9}{400} = 0.079$$

$$\gamma = \frac{400 - 2*40 - 2*10 - 16}{400} = 0.7$$

$$for \gamma = 0.6 .... \frac{\phi * Pn}{Ag} = 2.15 KSI$$

$$for \gamma = 0.75 .... \frac{\varphi * Pn}{Ag} = 2.22 KSI$$

$By.\text{int}\ erpolation:$

$$For \gamma = 0.7 .... \frac{\phi * Pn}{Ag} = 2.19$$

$$and \rho = 0.0175$$

$A_{st} = \rho_g \times A_g = 0.0175 \times 400 \times 400 = 2800\ mm^2$ … …

USE 12 ϕ16 With As > As required

✓ <u>Design of the Stirrups</u>:-

The spacing of ties shall not exceed the smallest of :-

$$spacing \leq 16 \times d_b = 16 \times 1.6 = 25.6\ cm$$

$$spacing \leq 48 \times d_s = 48 \times 1.0 = 48\ cm$$

$$spacing \leq least\ \dim = 50\ cm$$

$Use \phi 10 @ 20\ cm$

4.6 DESIGN OF ISOLATED FOOTING (Group F1)

❖ Material: -

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

Load Calculations: -

Dead Load = 500 KN, Live Load = 200 KN

Total services load = 500 + 200 = 700 KN

Total Factored load = 1.2*500 + 1.6*200 = 920 KN

Column Dimensions (a*b) = 40 * 40 cm

Soil density = 18 Kg/cm3

Allowable Bearing Capacity = 400 KN/m2

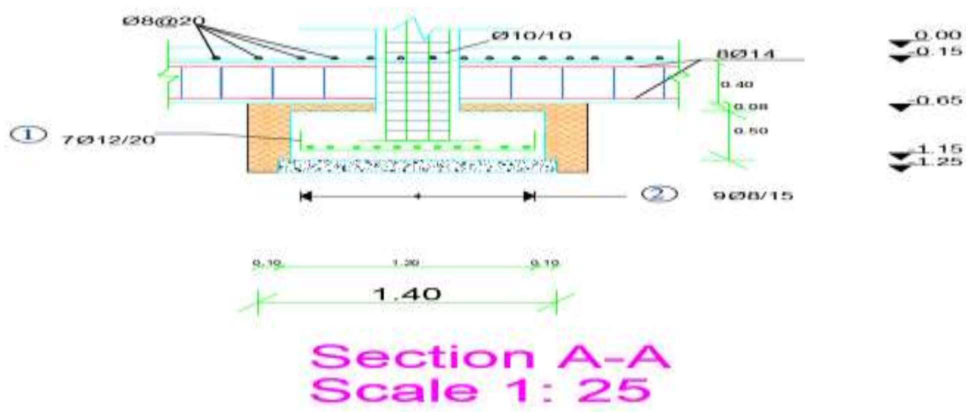


Fig 4.9: Foundation Section

Assume h = 50 cm

$q_{net-allow}$ = 400 – 25*0.5 – 18*0.4 – 5= 375.3 KN/m2

- ✓ Area of Footing:-

$$A = \frac{Pt}{q_{net-allow}} = \frac{700}{375.3} = \ 1.86\, m^2$$

Assume Square Footing

Select B = 2m

- ✓ Bearing Pressure: -

q_u = 920 / 2 * 2 = 230 KN/m^2

Design of One-Way Shear Strength: -

Critical Section at Distance) d) From the Face of Column

Assume h = 50 cm, bar diameter ø 12 for main reinforcement and 7.5 cm Cover

d = 500– 75 – 12 = 413 mm

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

Vu =230 $* \left(\frac{2-0.40}{2} - 0.431\right) * 2$ = 169.74 KN

Vc= $\frac{1}{6}\sqrt{fc}$ bw d = $\frac{1}{6}\sqrt{24}$ *1500*413 = 505.82 KN

ØVc $= 0.75 * 11.44 = 379.4$ KN $> Vu$

- **SAFE.**

- ***Design of Two-Way Shear Strength***: -

$Vu = Pu - FR_b$

$FR_b = q_u * area \quad of \quad critical \quad sec\,t\,ion$

$Vu = 920 \; - 230\,[(0.4 + 0.413) * (0.4 + 0.413)] = 546.02\; kN$

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

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

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

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

Where:

$$\beta_C = \frac{Column \quad Length \quad (a)}{Column \quad Width \quad (b)} = \frac{40}{40} = 1$$

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

$$b_o = 2 * (4.13 + 40) + 2 * (4.13 + 40) = \quad 176.52 cm$$

α_s = 40 \ for interior column

$$\varphi . V_C = \varphi . \frac{1}{6}\left(1 + \frac{2}{\beta_c}\right)\sqrt{f_c{}'}\, b_o d = \frac{0.75}{6} * \left(1 + \frac{2}{1}\right) * \sqrt{24} * 1765 * 413 = 1339.16\; kN$$

$$\varphi . V_C = \varphi . \frac{1}{12}\left(\frac{\alpha_s}{b_o/d} + 2\right)\sqrt{f_c{}'}\, b_o d = \frac{0.75}{12} * \left(\frac{40 * 413}{1765} + 2\right) * \sqrt{24} * 1765 * 413$$

$$= 2535.42\; kN$$

$$\varphi . V_C = \varphi . \frac{1}{3}\sqrt{f_c{}'}\, b_o d = \frac{0.75}{3} * \sqrt{24} * 1765 * 413 = 892.8\; kN$$

ΦVc =892.8 kN> Vu

∴ ok

1- Design of Bending Moment:

Critical Section at the Face of Column

FR = $q_u * \left(\frac{B-a}{2}\right) * L$ = 230* $\left(\frac{2-0.40}{2}\right)$ *2= 368 kN

Mu = 230 *2*1.25*1.25/2 = 359.4 kN.m

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{359.4\times10^6}{0.9\times2000\times413^2} = \ 1.17Mpa$

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

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times1.17}{420}}\right) = 0.006$

$A_{s,req} = \rho.b.d = 0.006\times2000\times413 = 4956\ mm^2$

$A_{s,min} = 0.0018*2000*500 = 2700\ mm^2$

$A_{s,req} > A_{s,min}$

Check for Spacing:

S = 3h = 3*50 = 150 cm

S = 45 cm ……… is control

<u>Use 26 ø12 in Both Direction</u>

Check for strain:

$a = \frac{A_s.f_y}{0.85b\ f_c'} = \frac{4956\times420}{0.85\times2000\times24} = 51.01mm$

$c = \frac{a}{\mathcal{B}_1} = \frac{51.01}{0.85} = 60.01\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{413-60.01}{60.01}\right) = 0.018 > 0.005\ \ldots\ldots\boldsymbol{0k}$$

4.7 DESIGN OF STAIRS

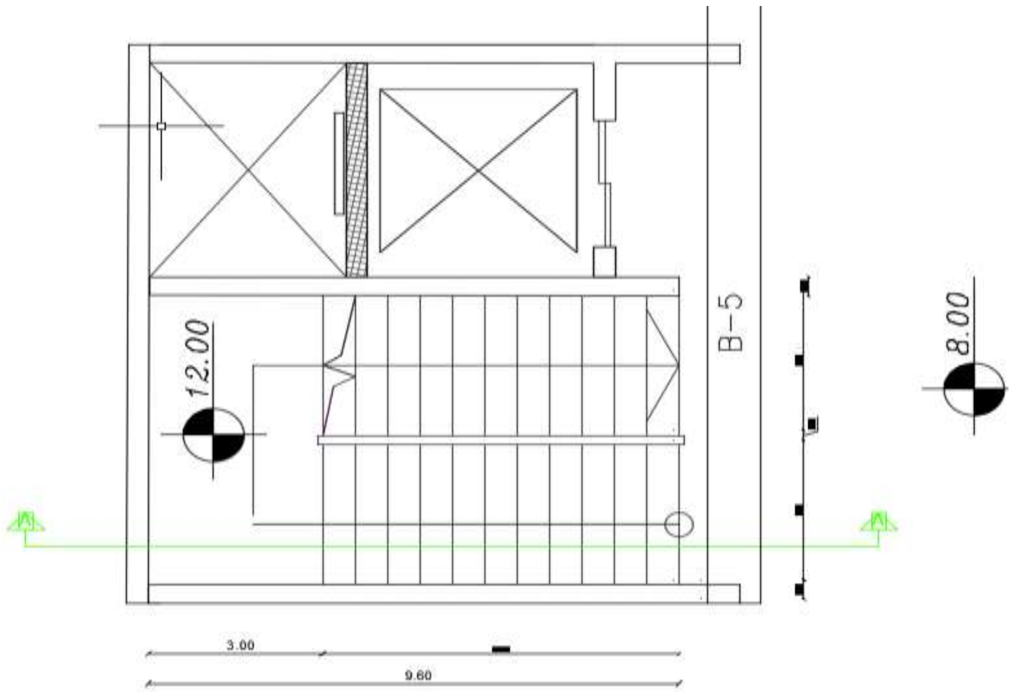


Fig 4.10 Stair Plan.

Material :-

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

Design of Flight: -

✓ Determination of Thickness: -

$h_{min} = L/20$

h_{min} = 4.80/20 = 24cm

Take h = 25 cm

The Stair Slope by $\theta = \tan^{-1}(19/30) = 32.35^o$

Load Calculation: -

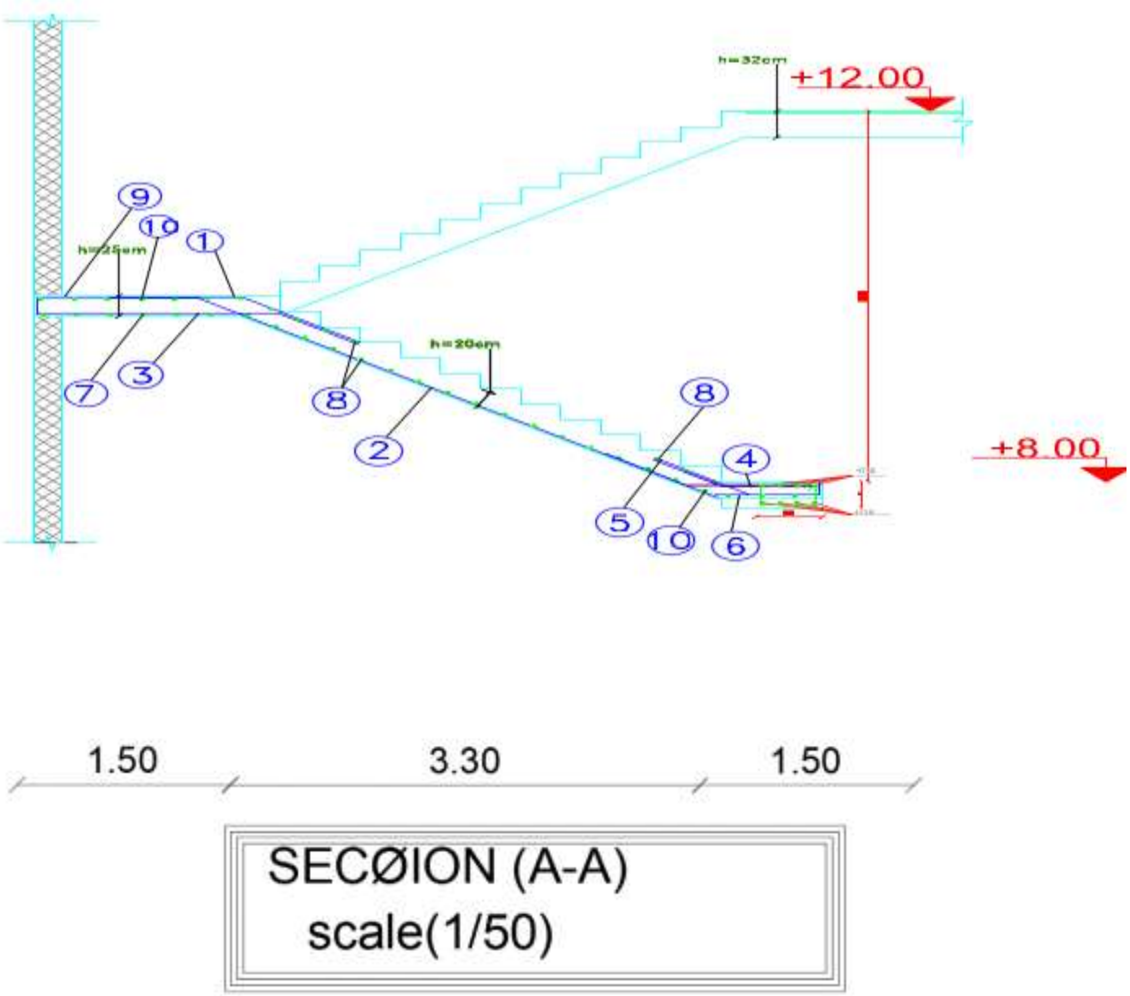


Fig 4.11: Stair Section

Load Calculations at section:

Load on Flight:

No.	Parts of Flight	Calculation	
1	Tiles	23*0.03*1*(0.36+0.19/0.3) = 1.265KN/m	
2	Mortar	22*0.03*1*(0.36+0.19/0.3) = 1.21KN/m	
3	Stair	25/0.3*(0.190*0.3/2) *1 =2.375 KN/m	
4	R.C	25*0.25*1/ cos 32.35 ^{o} = 7.39 KN/m	
5	Plaster	22*0.02*1 / cos 32.35^{o} = 0.521KN/m	
		Sum	12.761 KN/m

Tables4.3: Dead Load For Flight For 1m Strip

Live Load For Landing For 1m Strip = 5 KN/m

Factored Load For Flight

W_U = 1.2 ×12.8+ 1.6×5 = 23.36 KN/m

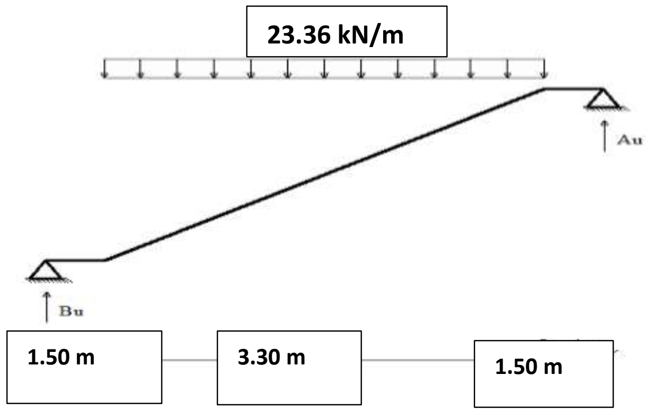
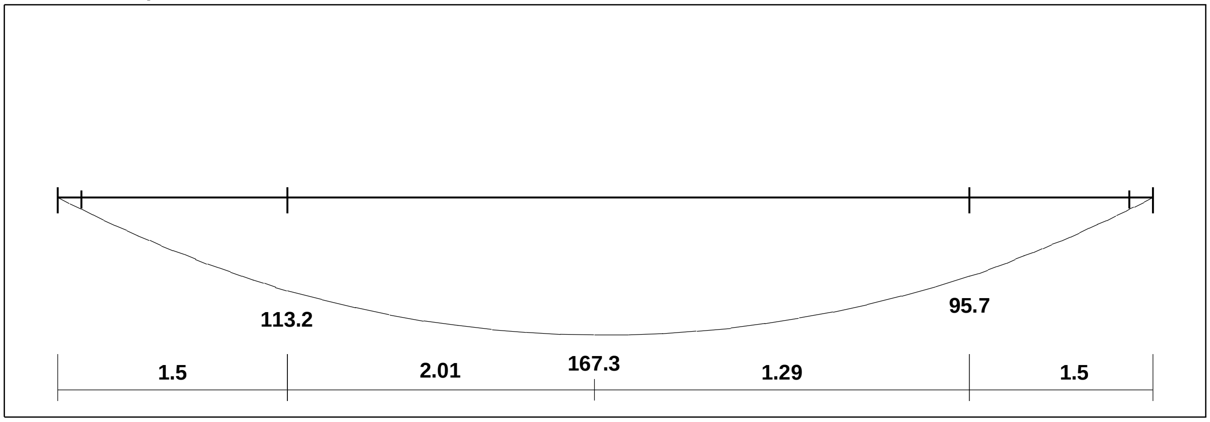


Fig 4.12: Statically System and Loads Distribution of Flight.

M o m e n t / S h e a r E n v e l o p e (Factored) Units:kN,meter

Moments: spans 1 to 3



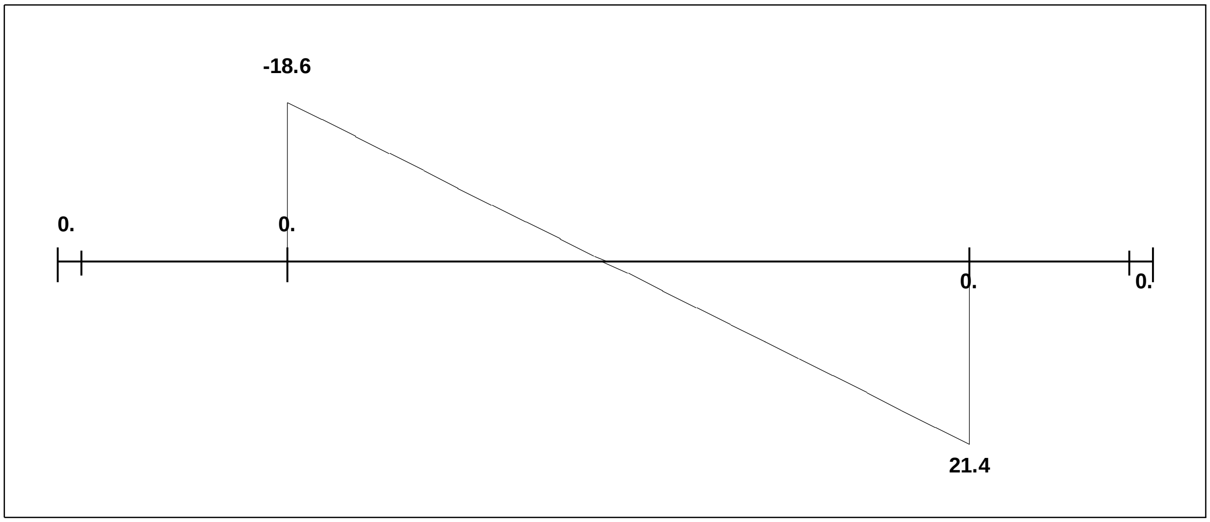


Fig 4.13: Shear and Moment Envelope Diagram of Flight

Assume bar diameter ø 20 for main reinforcement

1- Design of Shear for Flight :- (Vu=21.4 KN)

d =h- cover $-\frac{d_b}{2} = 250 - 20 - \frac{20}{2} = 220\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d = \frac{1}{6}\sqrt{24} * 1500 * 220 = 269.44$ KN

Φ V_c = 0.75* 269.44 = 202.08 KN > Vu = 21.4 KN…… **Thickness Is Enough**

2- Design of Bending Moment for Flight :- (Mu=167.3KN.m)

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{167.3\times10^6}{0.9\times1500\times220^2} = 2.56\ Mpa$

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

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times2.56}{420}}\right) = 0.0066$

$A_{s,req}$ = ρ.b.d = 0.0066 ×1500×220 = 2178 mm^2

$A_{s,min}$= 0.0018*1500*250 = 675 mm^2

$As_{req} > A_{s,min}$=2168 mm^2……… **is control**

Check for Spacing :-

S = 3h = 3*250=750 mm

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

S = 450 mm

S = 330 mm ……… **is control**

Use ø20 @ 200 mm , $A_{s,provided}$= 2198 mm^2>$A_{s,required}$= 2168 mm^2… Ok

Check for strain: -

a $=\frac{A_{s.}f_y}{0.85b\ f_c'}=\frac{2198\times420}{0.85\times1500\times24}=30.5\ mm$

c$=\frac{a}{\mathcal{B}_1}=\frac{30.5}{0.85}=35.9\ mm$

$$\varepsilon_s=0.003\left(\frac{d-c}{c}\right)=0.003\left(\frac{220-35.9}{35.9}\right)=0.0154>0.005\quad \dots\dots\boldsymbol{0k}$$

3- Lateral or Secondary Reinforcement for Flight: -

$A_{s,\ req}= A_{s,\ min}$ =0.0018*1500*250 = 675mm^2

Use ø12@ 150 mm, $A_{s,\ provided}$= 678.6 mm^2>$A_{s,\ required}$= 675mm^2… Ok

Design and System of Landing:-

No.	Parts of Landing	Calculation
1	Tiles	22*0.03*1= 0.66 KN/m
2	Mortar	22*0.03*1= 0.66 KN/m
4	R.C	25*0.25*1= 6.25 KN/m
5	Plaster	22*0.02*1= 0.44 KN/m
	Sum	8.01 KN/m

Table (4.4): Dead Load Calculation of Landing.

Calculation of thickness:

h_{min} = L/20

h_{min} = 4.2/20 = 21 cm

Take h = 25 cm

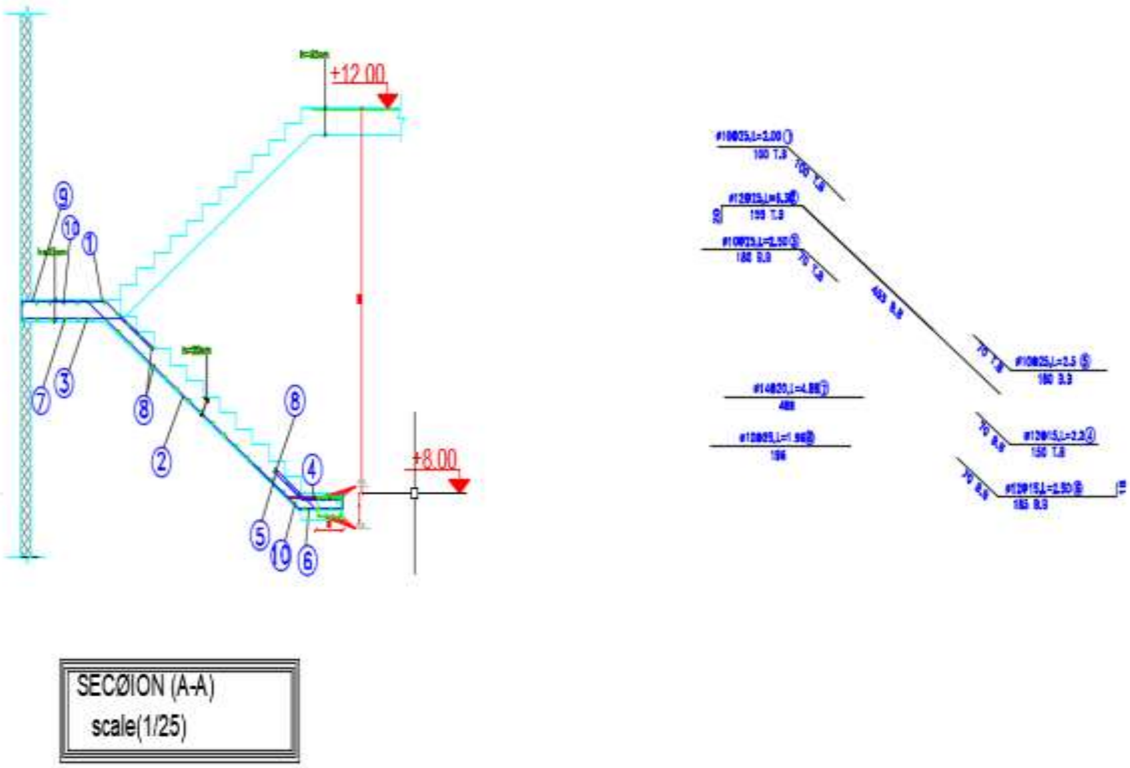


Fig 4.14: Stair Reinforcement.

4-11 Design Of Basement Wall

4.9.1 Load Calculation:

$\gamma = soildensity = \ 18KN/m^3$.

$\emptyset = angleofinternalfriction = 35°$.

LL=5 KN/m^2.

Thickness = 30cm, cover = 4cm.

The design will be for 1m width.

Neglect the axial load, since its low value

$q1 = soilpressure = Ko * \gamma * h$.

$q2 = surchargepressure = \ Ko * LL$.

$Ko = soilpressurecoefficientatrest = \ \ 1 - \sin \emptyset$.

So ,$Ko = 1 - \sin \emptyset = 0.426$.

$$q1 = 0.426 * 18 * 3.50 = 23.004 \frac{KN}{m^2}.$$

$$q2 = 0.426 * 5 = \ 2.13 \frac{KN}{m^2}.$$

Factored Load:

$q1u = 23.004 * 1.6 = 36.8 \ KN/m^2$

$q2u = 2.13 * 1.6 = 3.408 \ KN/m^2$

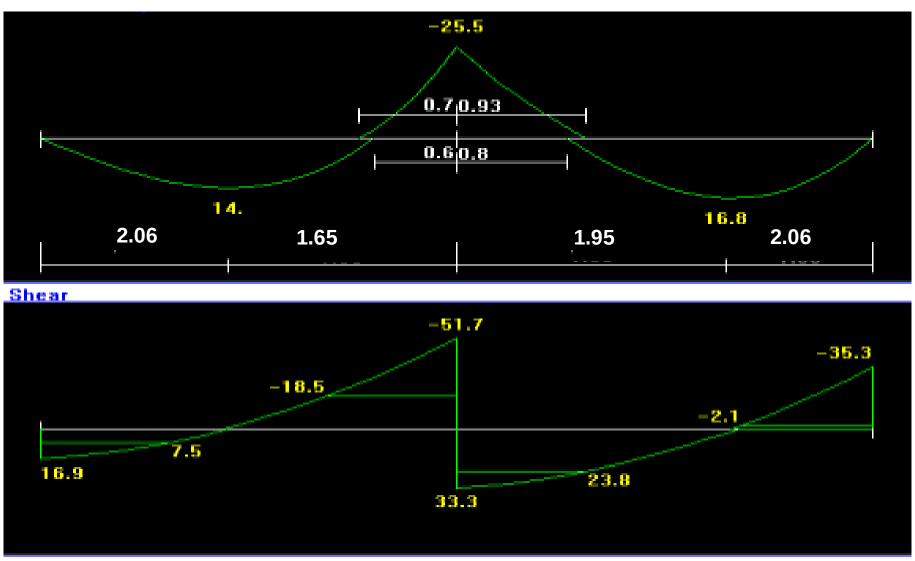


Figure 4. 15Moment /Shear Envelope

4.9.2 Design of bending moment of wall:

Design for negative moment Mu =-23.8 KN.m.

$$d = 300 - 40 - \frac{16}{2} = 252\ mm.$$

$$Mn = \frac{Mu}{0.9} = \frac{23.8}{0.9} = 26.4 KN.m$$

$$Rn = \frac{Mn * 10^6}{b * d^2} = \frac{23.8 * 10^6}{1000 * 252^2} = 0.375\ Mpa.$$

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

$$\rho = \frac{1}{m} * \left(1 - \sqrt{1 - \frac{2 * Rn * m}{Fy}}\right) = \frac{1}{20.6} * \left(1 - \sqrt{1 - \frac{2 * 0.375 * 20.6}{420}}\right) = 9 * 10^{-4}$$

$$Asreq\ = \rho * b * d = 9 * 10^{-4} * 1000 * 252 = 227.08\ mm^2$$

$$Asminv = 0.0012 * b * h = 0.0012 * 1000 * 300 = 360\ mm^2. \dots . control.$$

Select $\emptyset 12@20cm = 565.4\ mm^2 > 360 mm^2$.

Design for positive moment Mu =16.8 KN.m.

$$d = 300 - 40 - \frac{16}{2} = 252\ mm.$$

$$Mn = \frac{Mu}{0.9} = \frac{16.8}{0.9} = 17.77\ KN.m$$

$$Rn = \frac{Mn * 10^6}{b * d^2} = \frac{17.77 * 10^6}{1000 * 252^2} = 0.28\ Mpa.$$

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

$$\rho = \frac{1}{m} * \left(1 - \sqrt{1 - \frac{2 * Rn * m}{Fy}}\right) = \frac{1}{20.6} * \left(1 - \sqrt{1 - \frac{2 * 0.28 * 20.6}{420}}\right) = 6.7 * 10^{-4}$$

$$Asreq\ = \rho * b * d = 6.7 * 10^{-4} * 1000 * 252 = 169.2 mm^2$$

$$Asminv = 0.0012 * b * h = 0.0012 * 1000 * 300 = 360\ mm^2\ \dots . control.$$

Select $\emptyset 12@20cm = 565.4\ mm^2 > 360\ mm^2$.

4.9.3 Design of shear force:

$$d = 300 - 40 - 8 = 252mm$$

$$\emptyset Vc = 0.75 * \frac{1}{6} * \sqrt{fc'} * b * d = 0.75 * \frac{1}{6} * \sqrt{24} * 1000 * 252 * 10^{-3} = 154.3\ KN.$$

$(\emptyset Vc = 154.3) > (Vu = 23)$.

No shear Reinforcement is required, and thickness of wall is adequate enough.

But horizontal Reinforcement due to Cracking:

$Asreqh = 0.002 * b * h = 0.002 * 1000 * 300 = 600mm^2/m.$

For one side $As = 300\ mm^2/m.$

Select for one side horizontal reinforcement $\emptyset 10@25cm = 314.16\ mm^2 > 300\ mm^2$

4-8 Design of a shear wall (S.W15):

To design shear walls we use (CSI ETABS)Software , and this is a manual example of shear wall design :

Fig. (4-16) Shear and Moment Diagrams of Shear wall

Fc = 24 MPa

Fy = 420 MPa

t=2.0 m. shear wall thickness

Lw = 6.0 m. shear wall width

Hw for first wall = 4.0 m story height

Hw for second wall = 3.5 m story height

Hw for third wall =4.5 m story height

1.Design of shear(Horizontal and Vertical Reinforcement)

$$\sum Fx = Vu = 150 + 265 + 345 = 760KN$$

The critical Section is the smaller of:

$$\frac{lw}{2} = \frac{6.0}{2} = 3.00m\ldots.control$$

$$\frac{hw}{2} = \frac{12}{2} = 6m$$

$$storyheight = 4m$$

$$d = 0.8 \times lw = 0.8 \times 6000 = 4800mm$$

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

$$= 0.75 * 0.83 * \sqrt{24} * 200 * 4800 * 10^3 = 2927KN$$

$V_c = \frac{1}{6}\sqrt{f_c{}'}hd = \frac{1}{6}\sqrt{24} * 200 * 4800 * 10^{-3} = 783.8\ KN$ Control

$$V_c = 0.27\sqrt{f_c{}'}hd + \frac{N_u d}{4l_w} = 0.27\sqrt{24} * 200 * 4800 + 0 = 1269.8\ KN$$

$$Mu = 4373.2KN.m$$

$$\frac{M_u}{V_u} - \frac{l_w}{2} = \frac{4373.2}{760} - \frac{6}{2} = 2.75 > 0\ (+ve\ value)$$

$$V_c = \left[0.05\sqrt{f_c} + \frac{l_w\left(0.1\sqrt{f_c{}'} + 0.2\frac{N_u}{l_w h}\right)}{\frac{M_u}{V_u} - \frac{l_w}{2}}\right]hd \quad = \left[0.05\sqrt{24} + \frac{6.0\left(0.1\sqrt{24} + 0\right)}{2.75}\right]200 * 4800 = 1261.2\ KN$$

Horizontal:-

P = 0.002 for $\emptyset < 16$

P= $\frac{\text{Ahmin}}{s.h}$, S = 39.25 cm

Use Ø 10 @ 25 cm in each side for each story.

Vertical:-

P = 0.0012 for $\emptyset < 16$

P = $\frac{\text{Ahmin}}{s.h}$, S = 52.3 cm

Use Ø 12@ 25 cm in each side for each story

---

2. Design for flexure:

$$A_{st} = \left(\frac{6000}{200}\right) * 2 * 113.04 = 6782.4mm^2$$

$$w = \left(\frac{A_{st}}{L_w h}\right)\frac{f_y}{f_c{}'} = \left(\frac{6782.4}{6000 * 200}\right)\frac{420}{24} = 0.09891$$

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

$$\frac{C}{l_w} = \frac{w + \alpha}{2w + 0.85\beta_1} = \frac{0.09891 + 0}{2 * 0.09891 + 0.85 * 0.85} = 0.107$$

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

$$= 0.9[0.5 * 6782.4 * 420 * 6000(1 + 0)(1 - 0.107)] = 6868.278KN.m > Mu \text{ OK}$$

Chapter 5

Results and recommendations

Results and recommendations

5.1 Results.

5.2 Recommendations.

5.3 References.

5.4 Appendix.

5.1 Results.

Through this research, and after analyze each part of the project, the results we got can be summarized as:

1- study the architectural plans and understand them have a major role in finding the most appropriate solutions to find the best type of construction system used in the building.

2- The ability to do manual calculation for the elements is necessary to create a good structural designer and to compare the manual solutions with the structural programs results and understand how they work.

3- Identify the structural elements, and how to deal with it, with its mechanism, and it is very important to design it taking into consideration safety and structural strength.

5.2 Recommendations.

1- There should be coordination between the architect and the structural designer during the design process to build an integrated building structurally and architecturally.

2- Recommends executing the project according to the architectural plans attached with the least changes.

3- It is advised to have a structural engineer in the project site to insure executing the work according to the required structural drawings.

4-it is essential to complete the electrical and mechanical design of the project before the start of any editing on it according to the final structural design of the project.

5.3 References.

1- Jordan's national building codes, coded loads and forces, the National Building Council Jordan, Amman, Jordan, 1990.

2- Supervising professor notes.

3- ACI Committee 318 (2008), ACI 318-08: Building Code Requirements for Structural Concrete and Commentary, American Concrete Institute, ISBN 0-87031-264.

4- Nawy, Edward, Prestressed Concrete Fifth Edition Upgrade: ACI, AASHTO, IBC Codes Version (5th Edition), 2009.

5.4 Appendix.

1-Appendix (A): Architectural Drawings “this appendix is an attachment with this project".

2.Appendix (B): Structural Drawings "this appendix is an attachment with this project".

3.Appendix (C):

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

	Minimum thickness, *h*			
	Simply supported	One end continuous	Both ends continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be damaged by large deflections.			
Solid one-way slabs	$\ell/20$	$\ell/24$	$\ell/28$	$\ell/10$
Beams or ribbed one-way slabs	$\ell/16$	$\ell/18.5$	$\ell/21$	$\ell/8$

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

Figure 5-1: Minimum thickness of no prestressed beams or one-way slabs unless deflections are calculated.