Palestine Polytechnic University

College of Engineering

Civil Engineering

Graduation Project

Structural Design for " Halhul Specialized Hospital " In Halhul City

Project Team

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Supervisor:

Dr. Maher Amro.

This project submitted to the College of Engineering in partial fulfillment of requirements of the Bachelor degree of Civil Engineering

Hebron – Palestine

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

Structural Design for the" Halhul Specialized Hospital " In Halhul City

submitted by

Taqi Al - Din Al Atrash & Taqi Al - Din Al Karaki

for partial fulfillment of the requirements for the bachelor's degree.

Project Approved by :

Dr. Maher Amro. (Supervisor) :

Signature:…………………………………………………………………….

Dr. Belal Almassri

Head of Civil Engineering Department

Signature:…………………………………………………………………….

DEDICATION

To Mom and Dad, family and friends.

To our competitors and supporters.

To caffeine and sugar, our companions through long nights.

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

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

Acknowledgement

Thanks be to Allah for this guidance and providence!

we would like to take the opportunity to whole heartedly thank to everyone who supported us

we especially thank:

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

All lecturers at the university.

we would especially like to thank Dr. Maher Amro, who extended Great effort on the project.

Everyone who helped in the project and got great help

ABSTRACT

Structural Design for " Halhul Specialized Hospital " In Halhul City

Supervisor: Dr. Maher Amro.

Project Team

Taqi Al – Din Al Atrash & Taqi Al – Din Al Karaki

The structural design is the most important design of the building after the architectural design necessary for the distribution of columns, walls, loads, the best prices and the highest levels of safety are the responsibility of the structural designer. In this project, a structural design will be made for the four-store Halhul Specialized Hospital with a total area of 6000 m^2.

The structural design stage is one of the most important stages that the building goes through, from locating the columns and shear walls and determining the appropriate structural system for the building and designing it into an executable building after studying the architectural plans , this project was selected for the importance of knowledge in the design of these buildings.

we will use the Jordanian code to determine live loads, the American code (ASCE-16) and the code (UBC-97) to estimate earthquake loads and we will design the elements depend on (ACI318-11) and we will use some programs:

AUTOCAD, ATIR, SAFE, ETABS

After the completion of the project, we expect to be able to make a structural design for all structural elements of the project in accordance with the requirements of the code.

الملخص :

التصميم الإنشائي هو اهم تصميم للمبنى بعد التصميم المعماري اللازم لتوزيع الاعمدة والجدران والاحمال وأفضل الأسعار واعلى مستويات الأمان تقع على عاتق المصمم الإنشائي وفي هذا المشروع سيتم عمل تصميم إنشائي لمستشفى حلحول التخصصي المكون من أربعة طوابق بمساحة إجمالية 6000م^2 .

ومرحلة التصميم الانشائي من اهم المراحل التي يمر بها المبنى من تحديد أماكن الاعمدة وجدران القص وتحديد النظام الانشائي المناسب للمبنى وتصميمه إلى مبنى قابل للتنفيذ بعد دراسة المخططات المعمارية.

تم اختيار هذا المشروع لأهمية المعرفة في تصميم هذه المباني.

ومن الجدير بالذكر اننا سوف نستخدم الكود الأردني لتحديد الاحمال الحية والكود الأمريكي (ASCE-16) والكود (UBC-97) لتقدير احمال الزلازل وللتصميم الانشائي سيتم الاعتماد على الكود الأمريكي (ACI318-11) ، كما وأنه سيتم الاعتماد على بعض البرامج :

AUTOCAD , ATIR , SAFE , ETABS

وبعد الانتهاء من المشروع نتوقع ان نكون قادرين على عمل تصميم إنشائي لجميع العناصر الهيكلية للمشروع بما يتوافق مع متطلبات الكود

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List of Abbreviations:

- **A_c** = Area of concrete section resisting shear transfer.
- **A_s** = Area of non-prestressed tension reinforcement.
- **$A_s^\backslash$ =** Area of non-prestressed compression reinforcement.
- **A_g** = Gross area of section.
- **A_v** = Area of shear reinforcement within a distance (S).
- **At** = Area of one leg of a closed stirrup resisting tension within a (S).
- **a** = The distance of the compression zone from the top of the section
- **b** = Width of compression face of member.
- **b_w** = Web width, or diameter of circular section.
- **c** = The distance of the neutral axis from the top of the section.
- **C_c =** Compression resultant of concrete section.
- **C_s** = Compression resultant of compression steel.
- **D.L** = Dead loads.
- **d** = Distance from extreme compression fiber to centroid of tension reinforcement.
- **E_c** = Modulus of elasticity of concrete.
- **f_c** = Compression strength of concrete.
- **f_y** = Specified yield strength of non-prestressed reinforcement.
- **h** = Overall thickness of member.
- **L_n** = Length of clear span in long direction of two- way construction, measured face-to-face of supports in slabs without beams and face to face of beam or other supports in other cases.
- **L.L** = Live loads.
- **L_w** = Length of wall.
- **M** = Bending moment.
- **M_u** = Factored moment at section.

- $\mathbf{M_n}$ = Nominal moment.
- $\mathbf{P_n}$ = Nominal axial load.
- $\mathbf{P_u}$ = Factored axial load
- $\mathbf{R_n}$ = A strength coefficient of resistance.
- **S** = Spacing of shear or in direction parallel to longitudinal reinforcement.
- $\mathbf{V_c}$ = Nominal shear strength provided by concrete.
- $\mathbf{V_n}$ = Nominal shear stress.
- $\mathbf{V_s}$ = Nominal shear strength provided by shear reinforcement.
- $\mathbf{V_u}$ = Factored shear force at section.
- $\mathbf{W_c}$ = Weight of concrete. (Kg/m^3).
- **W** = Width of beam or rib.
- $\mathbf{W_u}$ = Factored load per unit area.
- X_{III} = the distance of region **III**.
- **Φ** = Strength reduction factor.
- ε_c = Compression strain of concrete = 0.003mm/mm.
- ε_s = Strain of tension steel.
- $\acute{\varepsilon}_s$= Strain of compression steel.
- **ρ** = Ratio of steel area.

CHAPTER 1
Introduction

1.1 Introduction

A lot of things in our life done by civil engineers, all buildings (houses, industrial buildings , facilities , bridges , commercial buildings … etc) , streets and drainage and sewage and water systems ,

The civil engineers draw the maps of the lands after measure it , plan, design , supervise, construct, and maintain buildings , bridges, tunnels, dams , railroads, highways, and airports.

1.2 General Overview

We chose a hospital graduation project located in Halhul, it's hospital specialized in eyes, nose, ear, throat and mouth, to provide to the graduation project and to conduct an integrated structural study that includes structural analysis and design of building elements so that they can with stand loads that affect the building.

1.3 Project Problem

The problem with this project in the analysis and structural design of all the components of the hospital building structural elements, which was adopted to be for this search, and in this area will be each element of the structural elements Such as slabs, ribs , columns, beams and foundation analysis, determining the loads located on them, and then determine the dimensions and design reinforcement it necessary, taking the factor of safety , and then will work details drawings for structural elements that have been designed, to take out of this project into the proposal into effect.

<u>why this project was chosen?</u>

There are many reasons that led to the selection of this project, including the reasons as follows:

1 - The project is a specialized hospital that enables us to cover the most things we studied and there is a difference in elements in hospitals (slabs, beams, columns …etc.) that lead to make a experience in design, analyze and detailing, in line with the scientific qualifications and skills that we gained through studying in the field of engineering.

2- Because this project is needed in our society and the need to implement buildings in an engineering manner.

3- The need to increase the experience and skill of structural design, which we studied .

1.4 Project Objectives

This Project was chosen to achieve the following goals:

- Make connections between the theory learned in design classes and real-life situations.
- Gain experience dealing with various challenges that arise during the design process.
- Apply theoretical knowledge as well as what we studied in structural analysis and design programs.

1.5 Work Procedure

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

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

1.6 The scope of the Project

Project contains several chapters are detailed as follows:

- **Chapter 1**: A general introduction to the project.
- **Chapter 2**: Includes description of architectural project.
- **Chapter 3**: Structural Description of the project
- **Chapter 4**: Analysis and structural design.

1.7 Time plan

Figure 1.1 The stages of the project

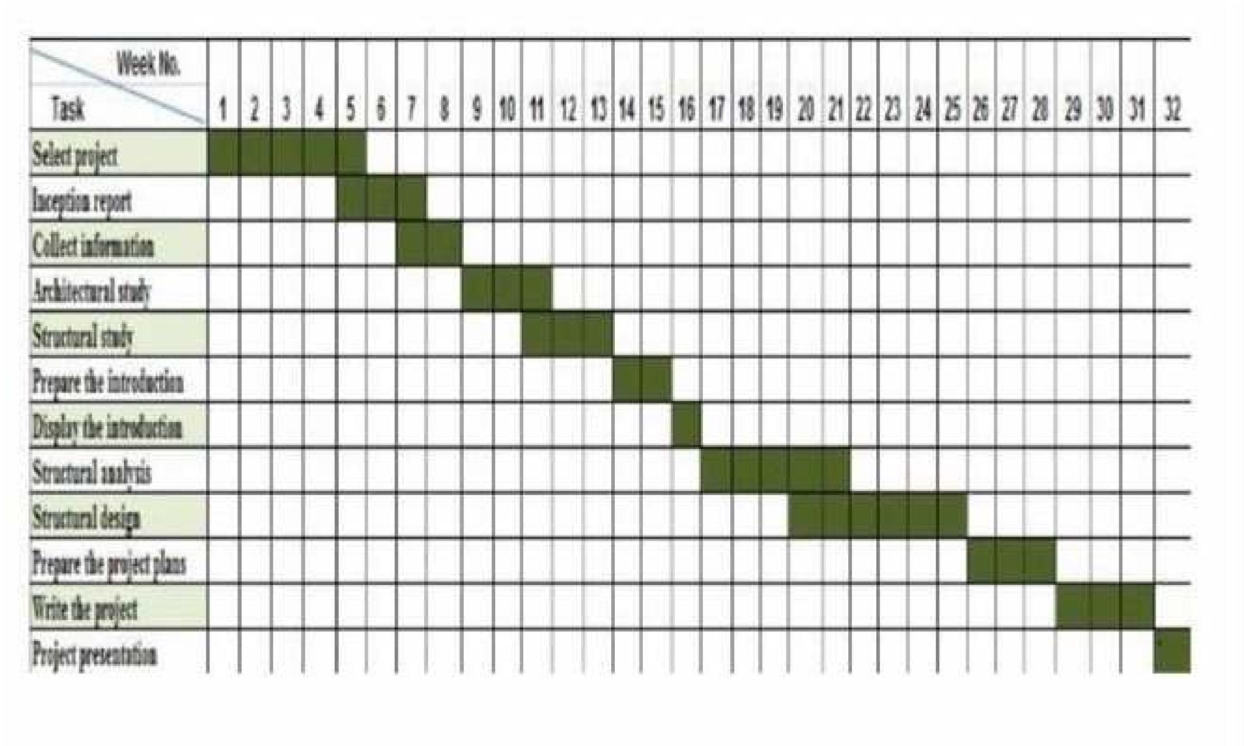

Table 1.1 TIME TABLE

1.7 programs we will use:

1. Microsoft Office for text writing and editing.
2. AUTOCAD 2020: for detailed drawings of structural elements.
3. ATIR18: Structural design and analysis of structural elements.
4. Safe16: design of slabs & footings .
5. SpCoulmn: for design the columns.
6. Found: for design foundation.
7. Etabs17: design of shear wall elements.

CHAPTER 2
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.

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

2.2 General identification of the project

The area of land 3878 m^2 it's located in Halhul , the hospital area of all floors approximately 6000m^2 it's contain 1 floor under ground & 3 floors over the ground there is a emergency and entrance on the east side

The basement floor area 1713 m^2 it contain 24 parking for cars , stores & pump , ground floor area 1580 m^2 and contain reception , laborites , pharmacy , x-ray rooms , doctors room , clinic room and maintenance room , first floor area 1620 m^2 and contain reception , central sterilization , clinic rooms eyes , noise ,ear and mouth , cafeteria, meeting room , kitchen , manager office , employers room , clinic rooms and manager of finance and doctors second floor area 997 m^2 , contain section of operation dep , doctor dining hall and terace .

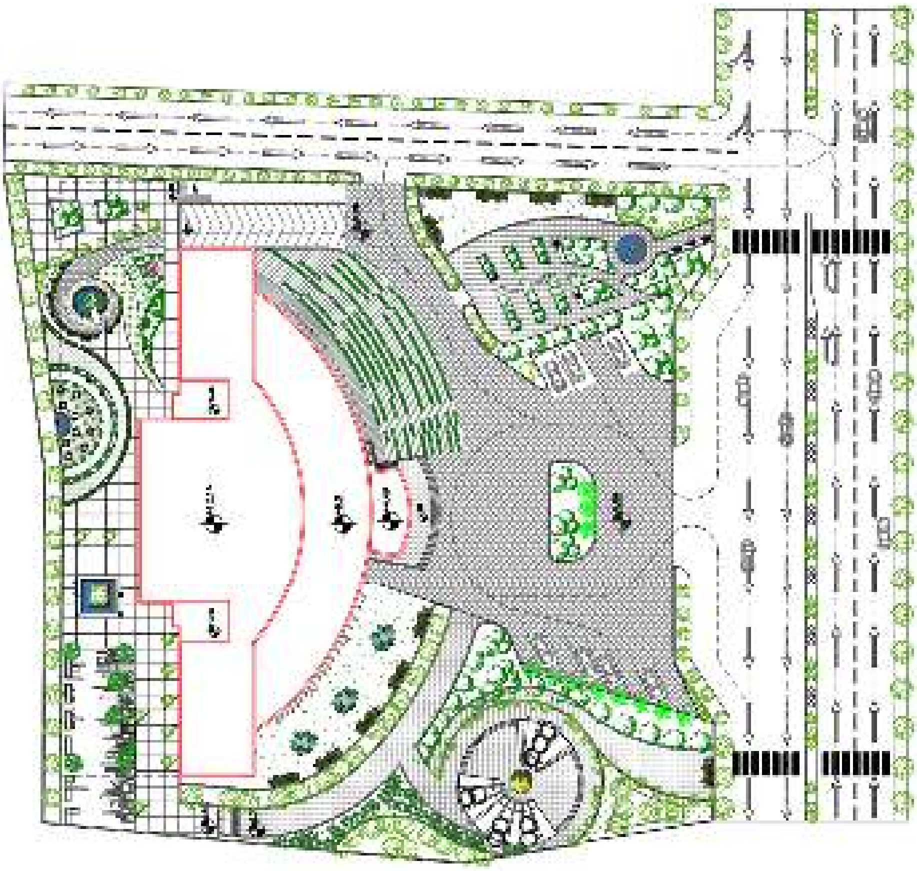

Fig (2.1): Site Plan Of Project.

2.3 General site description

The hospital located in Halhul north of Hebron, the area of land 3878 m^2 it's located opposite the Halhul police station, it's located about 5 km from Hebron, 30 km from Jerusalem, 25 km from Dead Sea and 60 km from The Mediterranean Sea, the plot of land is located in a convenient and easy to reach location for all Hebron residents, as it is located on main streets, the most important of which is Jerusalem – Hebron Street , and it is about 700 m away from the road (Street 60), This is what made this plot of land the most suitable location because it is located in a strategic and easy location Access.

The land of project	(red)
Jerusalem – hebron street	(yellow)
Halhul police station	(blue)
Halhul's southern	(black)

2.4 Floors description

Project contain one basement, ground floor , first floor and second floor , the area of all floors is approximately 6000m^2 and these sections describe the floors plans, elevations and sections

2.4.1 FIRST BASEMENT FLOOR

the area of this floor 1713 m^2 it contain 24 parking for cars , kitchen, boiler room , stores & pump .

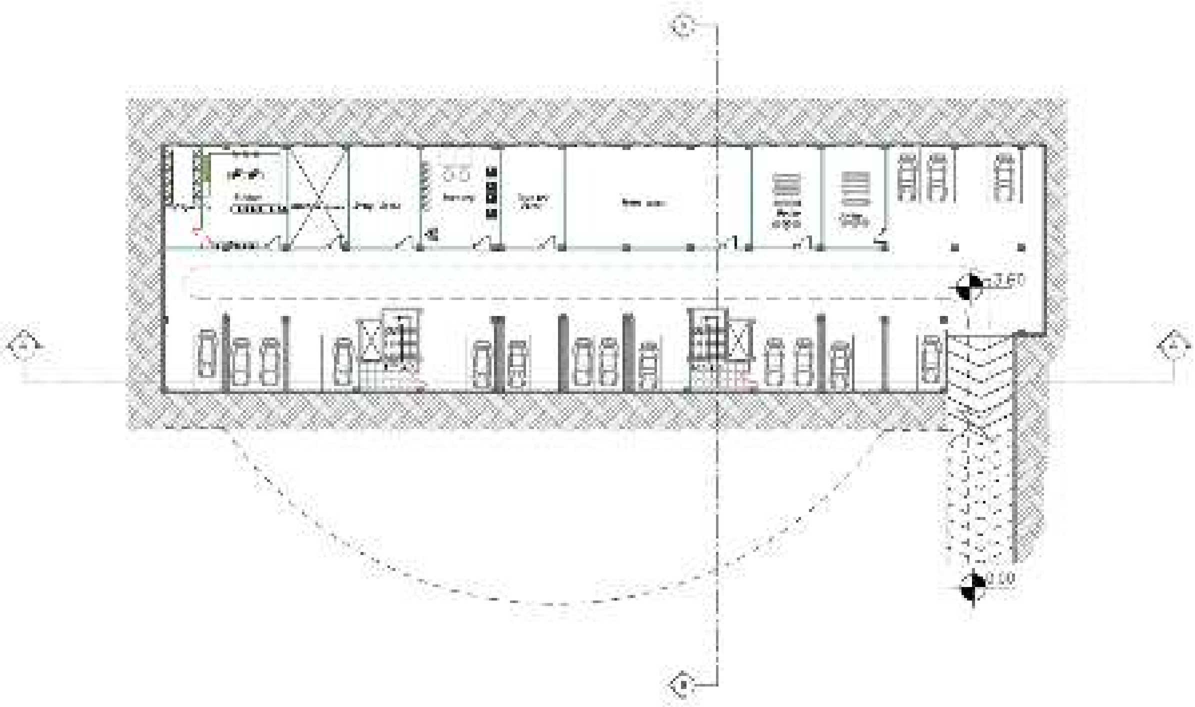

Fig (2.2): plan first basement floor.

2.4.2 GROUND FLOOR

the area of the floor 1580 m^2 and contain reception , laborites , pharmacy , x-ray rooms , doctors room , clinic room and maintenance room .

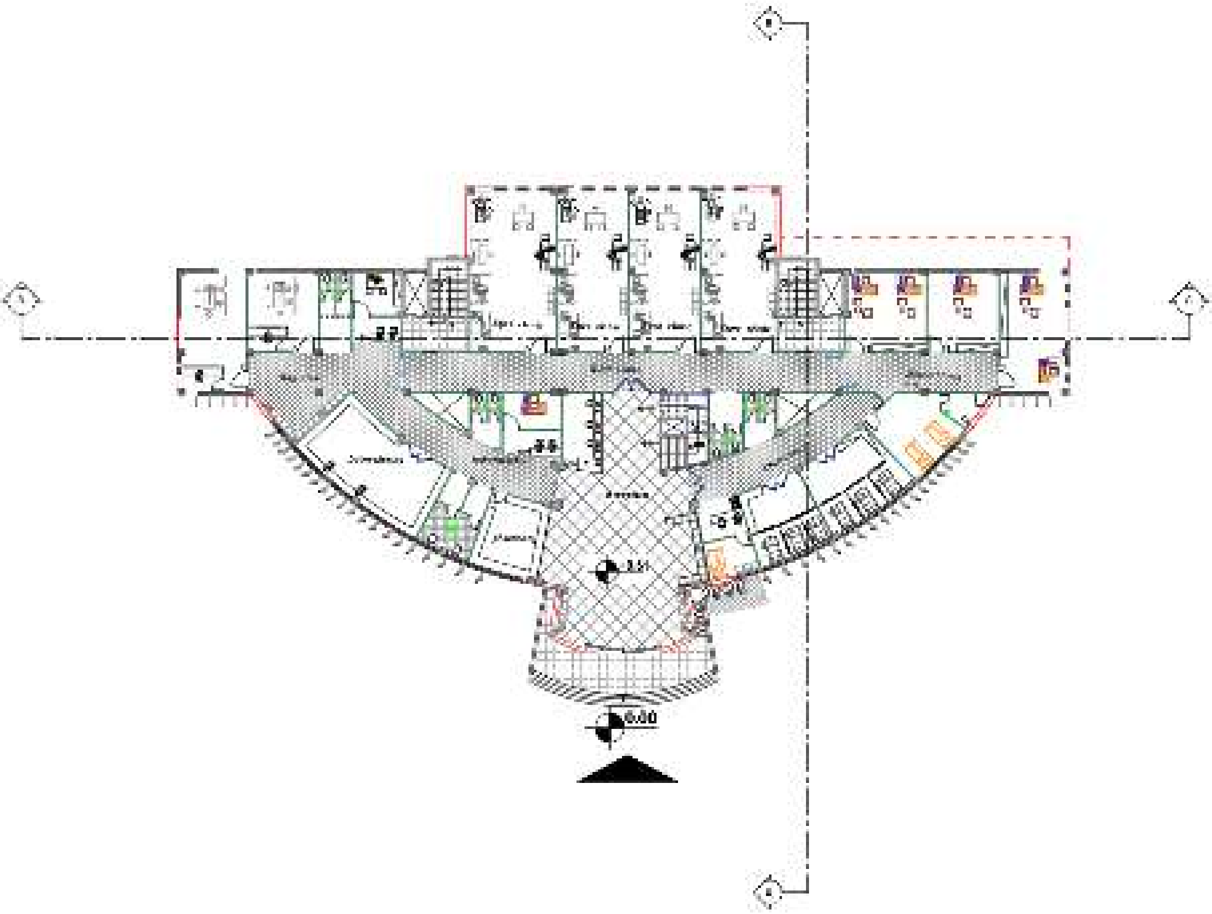

Fig (2.3): plan ground floor.

2.4.3 FIRST FLOOR

the area of the floor 1620 m^2 and contain reception , central sterilization , clinic rooms eyes , noise ,ear and mouth , cafeteria, meeting room , kitchen , manager office , employers room , clinic rooms, manager of finance and doctors

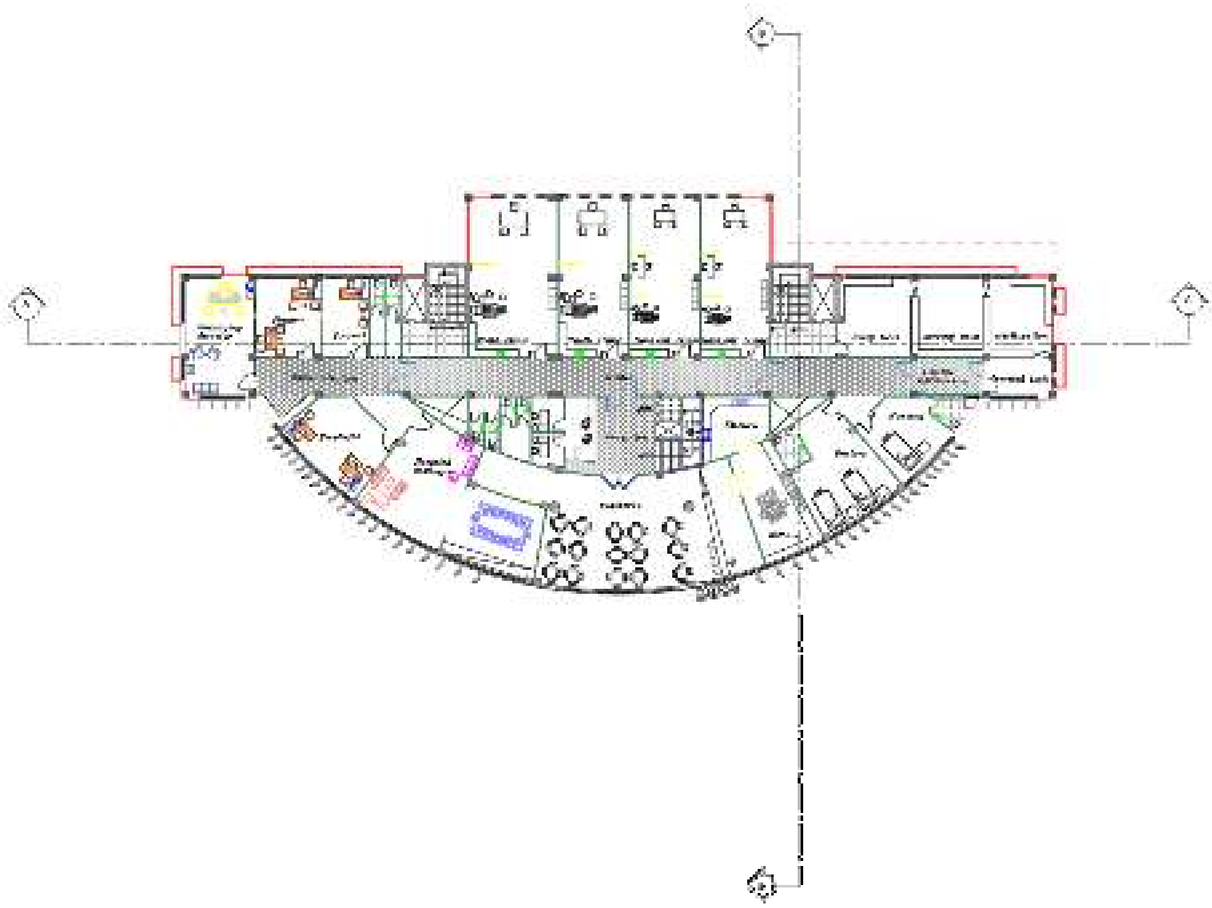

Fig (2.4): plan firs floor.

2.4.4 SECOND FLOOR

the area of floor 997 m^2 , contain section of operation dep , doctor dining hall and terace

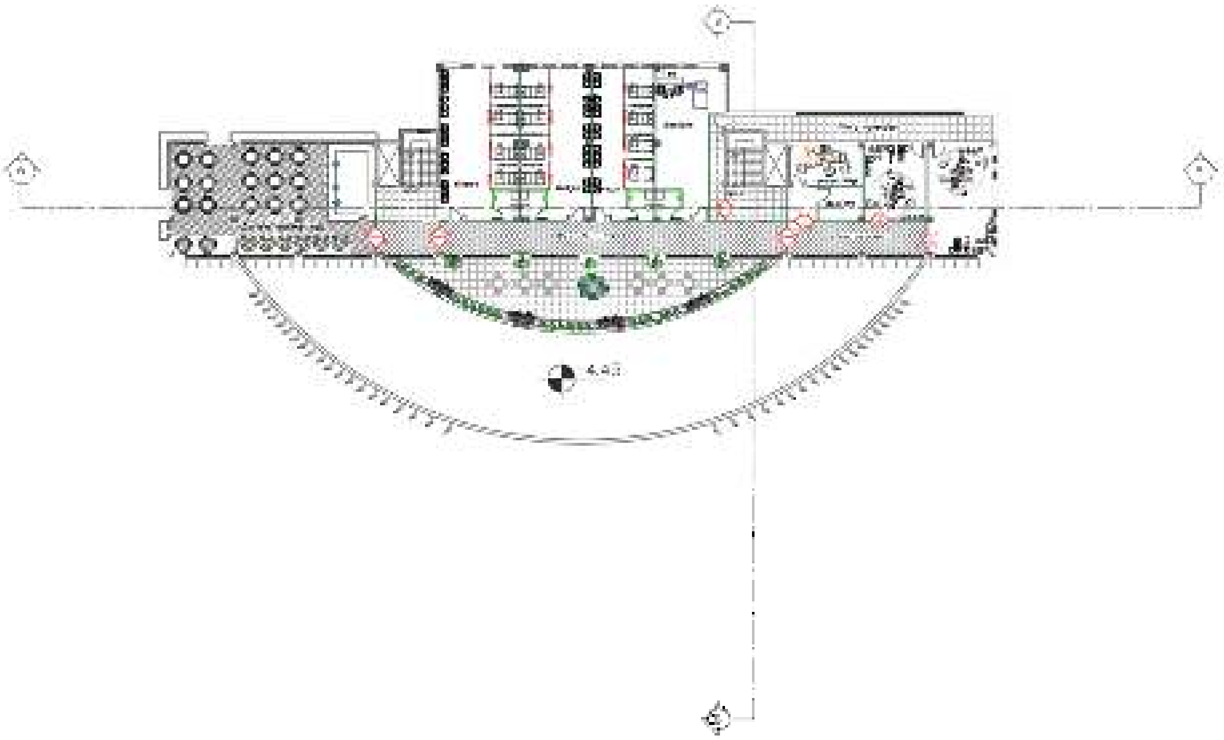

Fig (2.5): plan second floor.

2.5 ELEVATIONS DESCRIPTION

2.5.1 NORTH ELEVATION

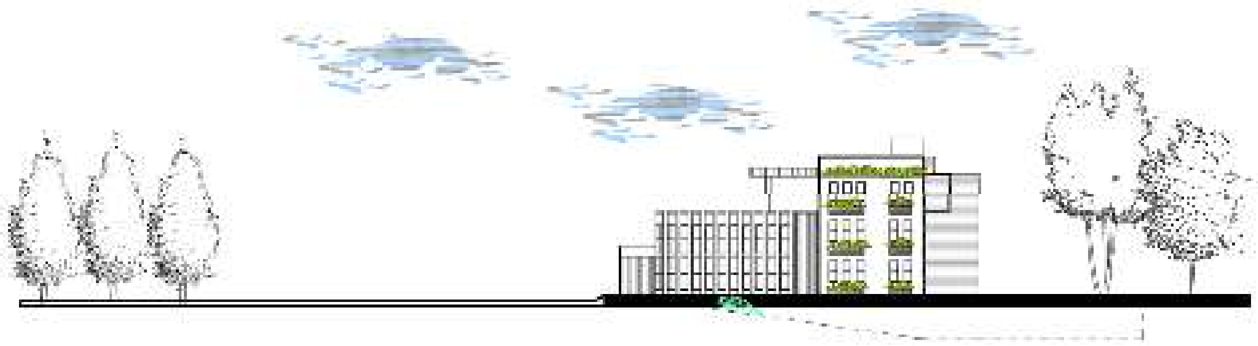

Fig (2.6): north elevation.

2.5.2 SOUTH ELEVATION

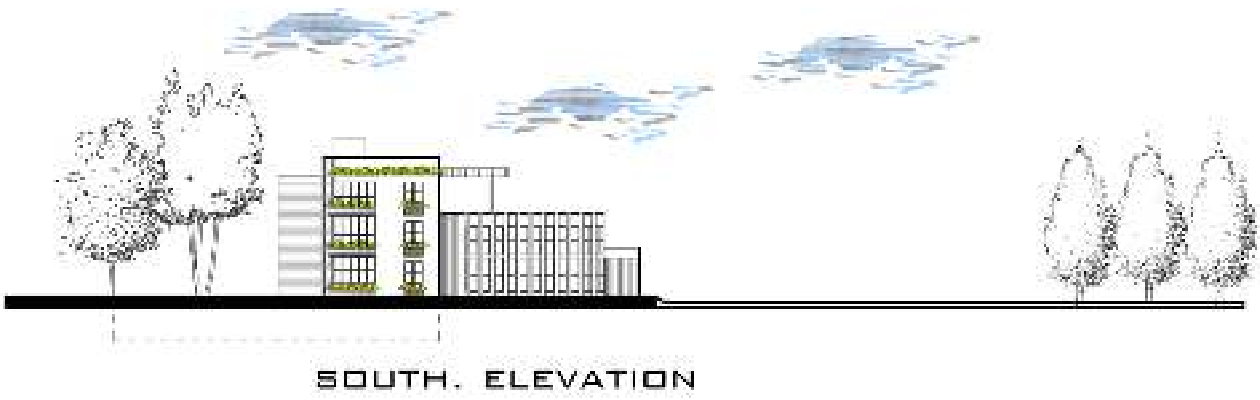

Fig (2.7): south elevation.

2.5.3 EAST ELEVATION

Fig (2.8): east elevation.

2.5.4 WEST ELEVATION

Fig (2.9): west elevation.

2.6 SECTIONS OF THE BUILDING

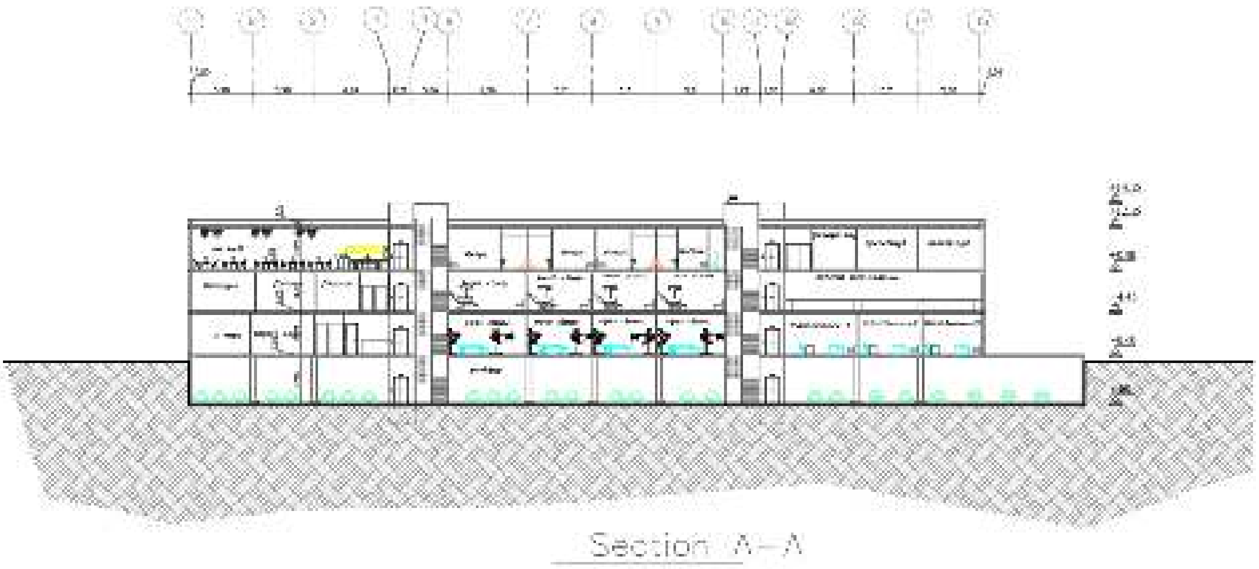

Fig (2.10): section A-A.

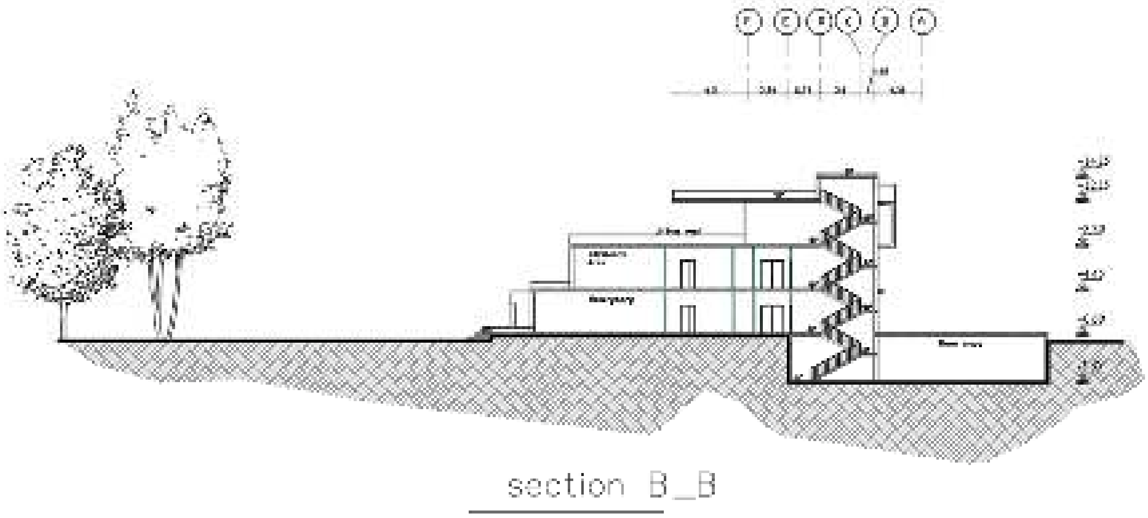

Fig (2.11): section B-B.

Chapter 3
Structural Description

3.1 Introduction

The main objective of the process design is to ensure the existence of necessary operating advantages with structural elements on the most suitable dimensions in terms of security andeconomic terms.

The knowledge of structural elements of any project is essential in the design of reinforced concrete structures to make comparisons between different types of these elements for the construction of safer system. So the structural elements that go into the design of this project will be described.

3.2 The aim of the Structural Design

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

1- Factor of Safety: Is achieved by selecting sections for structural elements capable of with standing the forces and resulting stresses.

2- Economy: Check by choosing the appropriate building materials and by choosing the perfect low-cost section.

3- Serviceability: To avoid excessive landing (deflection),

fissures (cracks).

4- Preservation of architectural design.

5- 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, and through holes up and depths measured.

3.4 Stages for Structural Design:

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

1. The first stage: - In this stage, the appropriate structural system of project construction and analysis for this system will be determined.

2. The second stage: - The structural design of each element of the set is detailed and accurate according to the chosen construction system and structural blue prints for executable

3.5 Loads Acting on the Building:

Is a group of forces that are designed to endure, and that any building is subjected to several types of loads must be calculated and selected carefully because any error in identifying and calculating loads reflects negatively on the structural design of various structural elements. The building is exposed to loads of live and dead loads, wind loads, snow loads, loads of earthquakes.

The permanent forces and resulting from strong gravity which are fixed in terms of amount and location and does not change during the age of the building, and the loads on the weight of structural elements and the weights of the items based upon sustainably as cutters and walls, as well as the weight of the body adjacent to the building permanently, and the calculation and estimate the loads by knowing the dimensions of the structural elements and specific gravity of the material used in the manufacture of structural elements, And are most often include: concrete, and Rebar, and plaster, and bricks, tiles and finishes, and the stone used in building coverage abroad, there is also a tube extension, as well as suspended ceilingsand decorations for the building.

3.5.1 Dead Loads

Material	Quality Density (kN/m^3)	Calculation	Dead Load (kN/m)
Tiles	23	= 0.03*23*0.54	0.373
Mortar	22	= 0.03*22*0.54	0.356
Sand	17	= 0.07*17*0.54	0.643
Topping	25	= 0.08*25*0.54	1.08
RC Rib	25	=0.27*25*0.14	0.945
Block	10	=0.27*10*0.4	1.08
Plaster	22	=0.03*22*0.54	0.356
Partitions		=2.76*0.54	1.49
∴ Dead Load for rib =6.32Kn/m / Rib			

Table (3-1) Determination of Dead load

3.5.2 Live Loads

Which are the loads that are subjected to buildings and constructions depending on varioususes, including distributed and concentrated loads, which include the following:

1. The weights of the Hospital users.

2. Dynamic loads, such as devices that produce vibration.

3. Static loads, which can be changed from time to time, such as furniture, machines, staticunstable machines, stored materials, equipments.

Live loads for hospitals from Jordanian code	5 KN/M^2

Table (3-2) Determination of live loa

3.5.3 Earthquake Load

Produce earthquakes of horizontal and vertical vibrations due to the relative motion of the Earth rock layers, resulting in strong cut affect the origin, and these loads must be taken into account in the design to ensure resistance to earthquakes. This will be resisted by shear walls designed with sufficient thickness and reinforcement to ensure the safety of the building when subjected to earthquakes loads that must be considered in the design process to reduce the risk and maintain the performance of the building, and determine the loads of earthquakesand shear forces depending on the American code (UBC).

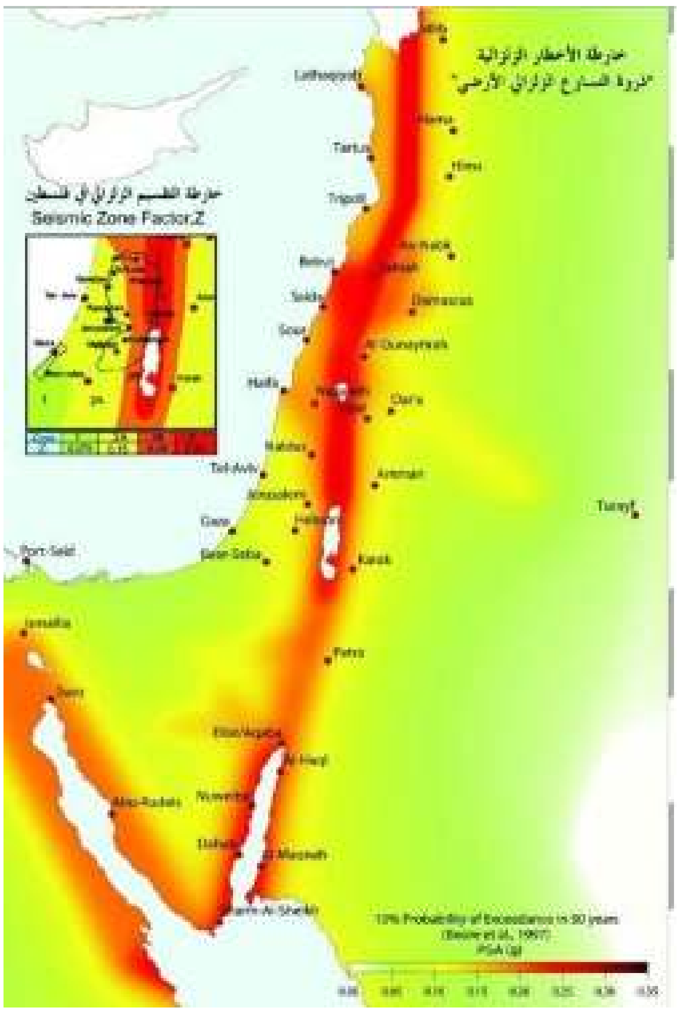

Fig (3.1) Earthquake map for palestine

3.6 Structural Elements of the Building

All buildings are usually consisting of a set of structural elements that work together to maintain the continuity of a building and its suitability for human use, and the most importantof these slabs and beams and columns and load-bearing walls, etc.

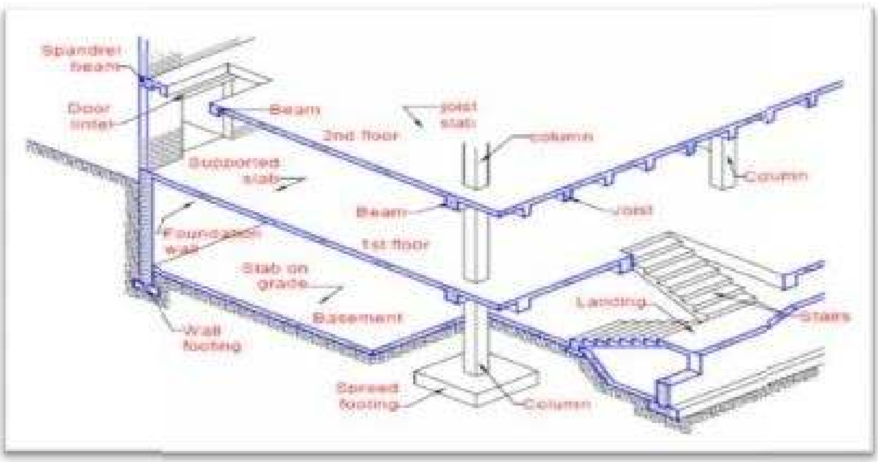

Fig (3.2) Structural Elements of the building

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, In this project, two types of components both in its appropriate place, and which will clarify the structural design in the subsequent chapter, and below two types:

One -Way Ribbed Slab
Two -Way Ribbed Slab
Flat slab

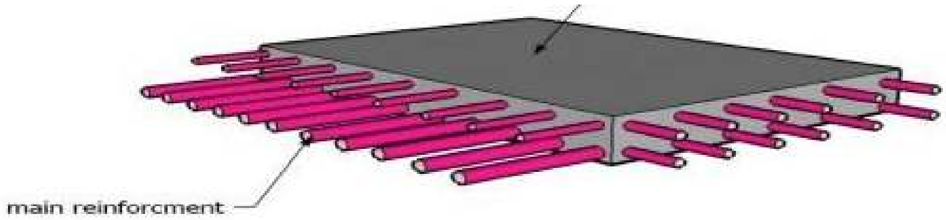

Fig. (3.3) flat Slab.

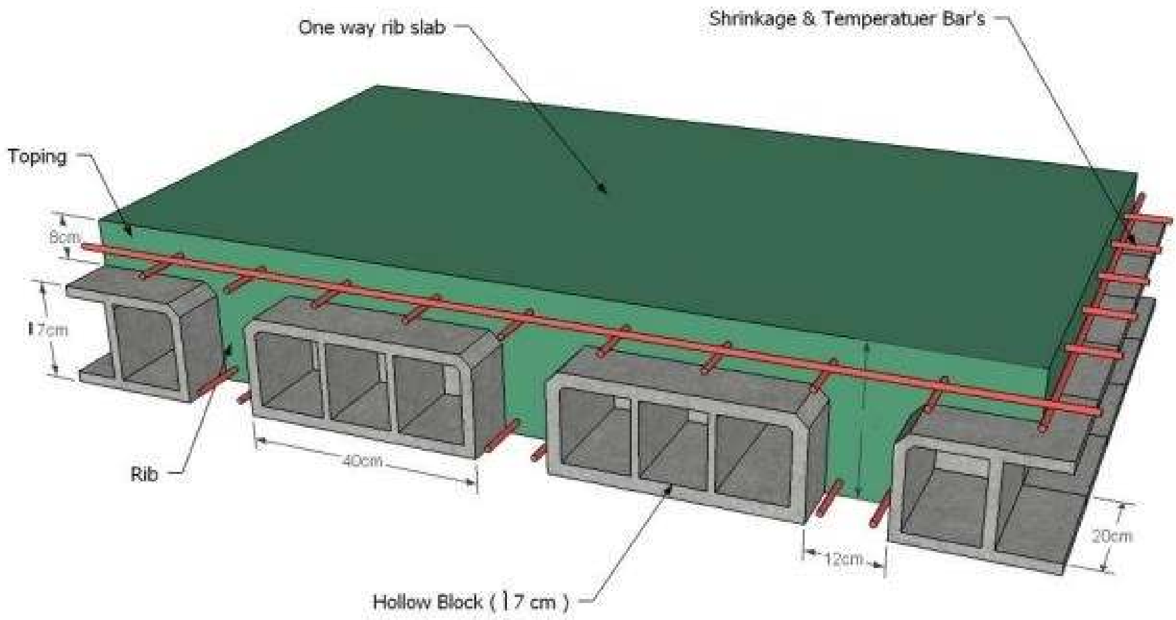

Fig. (3.4) One Way Ribbed Slab

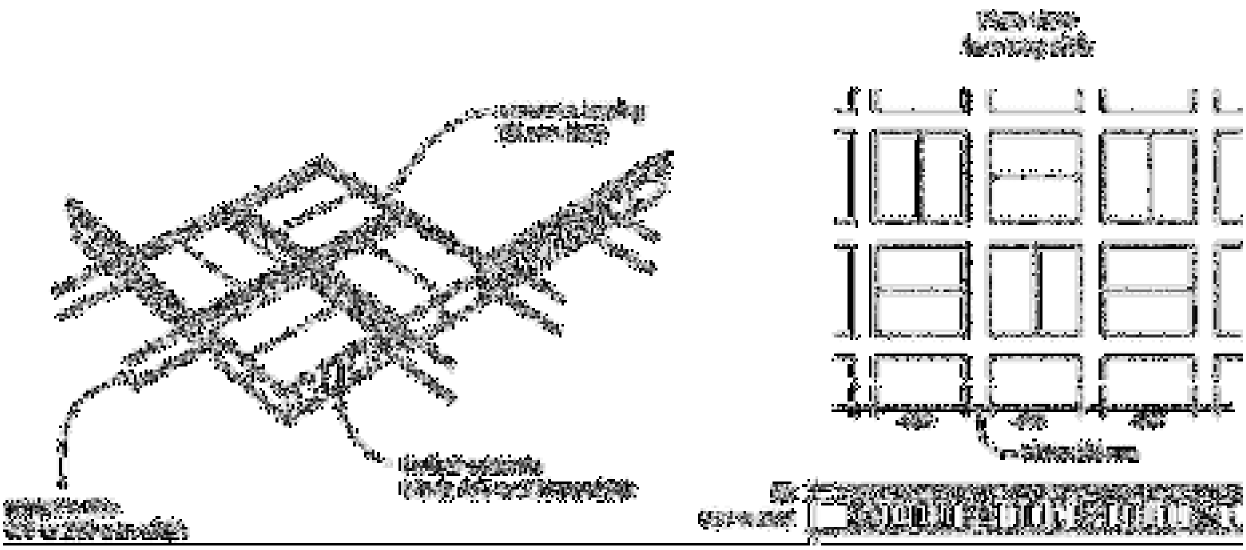

Fig. (3.5) Two Way Ribbed Slab

3.6.2 Stairs

The architectural elements used for vertical transmission between the different levels of through the building .

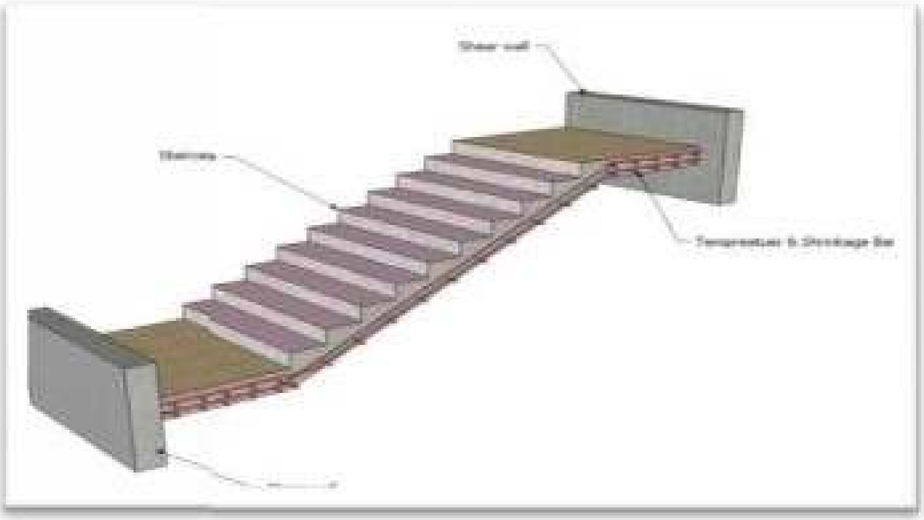

Fig. (3.6) Shape of stairs

3.6.3 Beams

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

1-Hidden Beam

2- Dropped Beam: (Drop Beam) like (T-section , L-section beams).

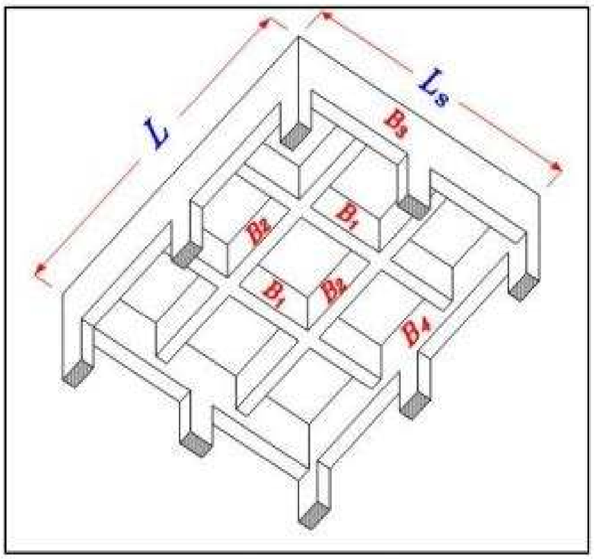

Fig. (3.7) Drop Beam

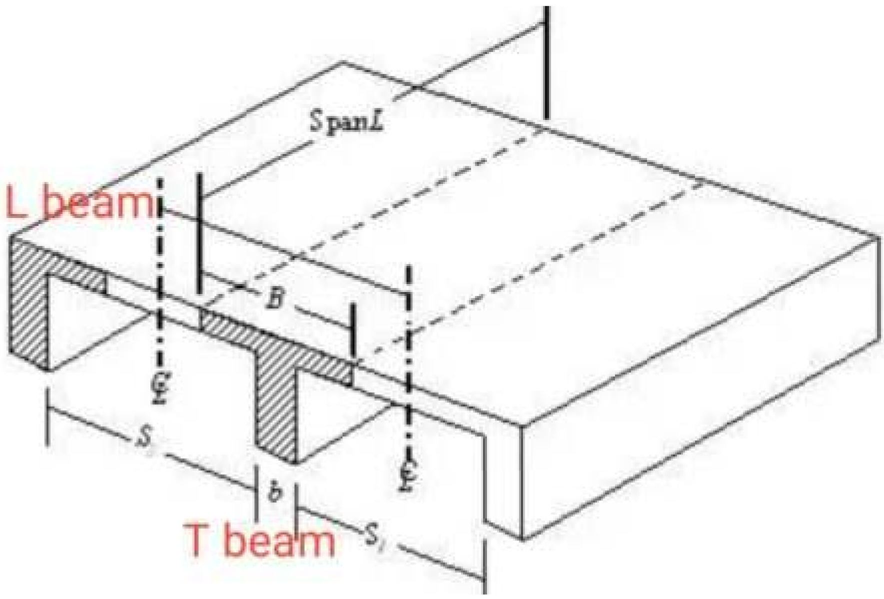

Fig. (3.8) T-Section and L-Section

3.6.4 Column

The column is an important element in moving loads of beams to the foundations, it is essential to transfer the loads of the building, and therefore must be designed so as to beable to resist the load.

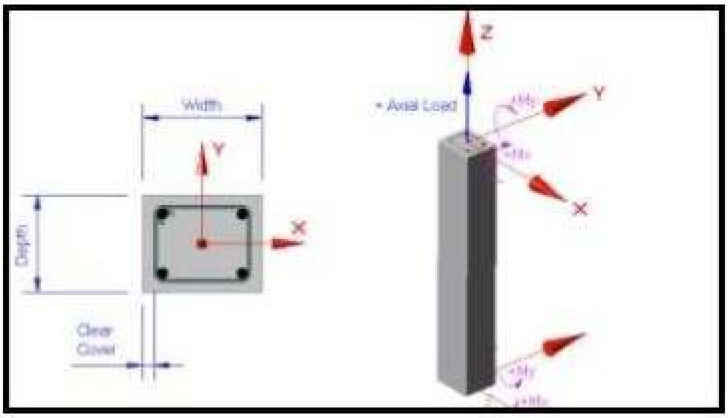

Fig. (3.9) Column

3.6.5 Shear Wall

Is a structural system composed of braced panels (also known as shear panels) to counter the effects of lateral load acting on the building, the building contains a number ofshear wall continued from Foundation to the end minaret.

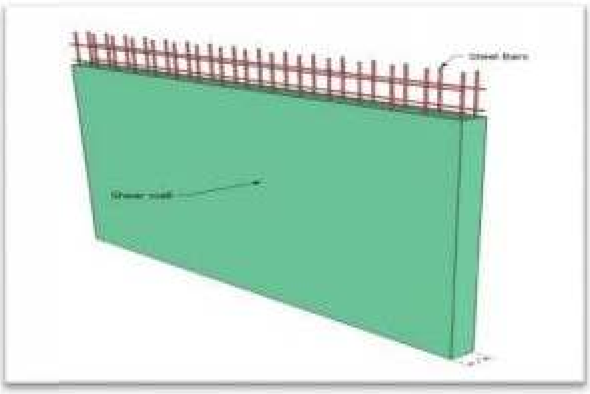

Fig. (3.10) Shear Wall

3.6.6 Foundation

Although the foundations are the first element constructs, but we did the design after the completion design all the structural elements in the building. The foundations are the link between the structural elements in the building and the earth. The loads on the slab move to the beams and then to the columns and finally to the foundations to the soil. The foundation is responsible for carrying the dead loads of the building and also the dynamic loads resulting from earthquakes. Also Live loads inside the building. We determined the type of foundations depending on the strength of the soil and the loads on each footing.

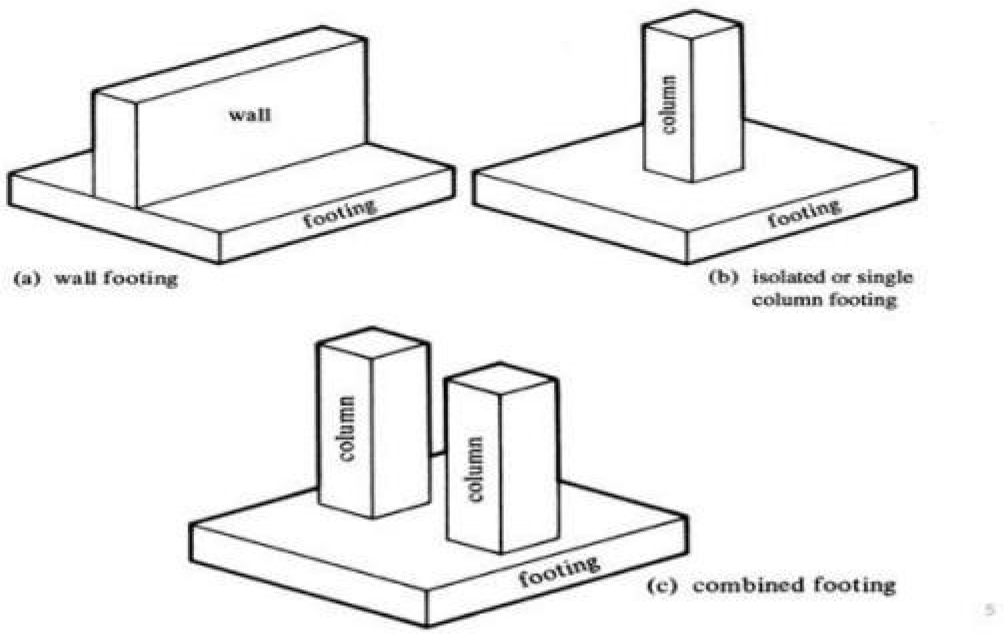

Fig. (3.11) Foundations

3.8 Structural programs we used

1. Microsoft Office for text writing and editing.
2. AUTOCAD 2020: for detailed drawings of structural elements.
3. ATIR18: Structural design and analysis of structural elements.
4. Safe16: design of slabs & footings .
5. SpColumn: for design the columns.
6. Found: for design foundation.
7. Etabs17: design of shear wall elements.

CHAPTER 4
Structural Analysis And Design

4.1 Introduction:

Concrete is a construction material composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate such as gravel, limestone, or granite, plus a fine aggregate such as sand), water, and chemical admixtures. The word concrete comes from the Latin word "concretus", which means "hardened" or "hard."

Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material. Concrete is used to make pavements, architectural structures, foundations, motorways/roads, bridges/overpasses, parking structures, brick/block walls and footings for gates.

In This Project, there are three types of slabs: flat plates two way ribbed slabs and one-way ribbed slabs. They would be analyzed and designed by using finite element method of design, with aid of a computer Program called " ATIR- Software" to find the internal forces, deflections and moments for ribbed slabs, and then hand calculation would be made to find the required steel for some members.

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-code

4 .2 Factored Loads.

The factored loads on which the structural analysis and design is based for our project members, is determined as follows:

qu = 1.2DL + 1.6L ACI – 318 - 08(9.2.1)

4.3 Determination of Thickness:

Determination of Thickness for One Way Rib 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):

Spans from left to right for one-way slab:

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

The minimum required thickness for hospital is:

The maximum span length for one end continuous (for ribs) is 6.1882m.

$h_{min} = \frac{l}{18.5} = \frac{6.45}{18.5} = \mathbf{34.8cm}$ >> **CONTROL**

The maximum span length for both end continuous (for ribs) is 6.1882m.

$h_{min} = \frac{l}{21} = \frac{6.93}{21} = 33$ cm

we select h= 35cm (27cm block + 8cm topping).

4.4 Load Calculation:

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:

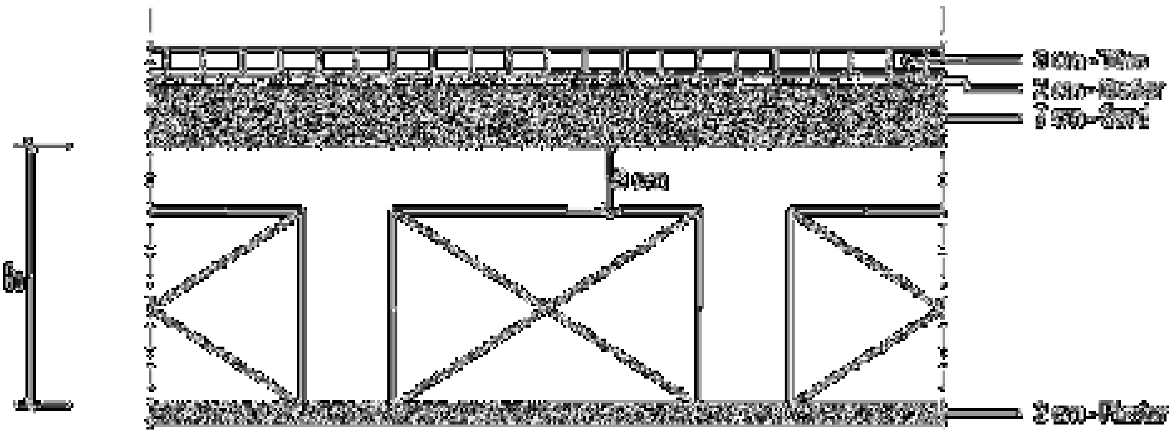

Fig. (4-1) One-way rib slab

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

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

Material	Quality Density (kN/m^3)	Calculation	Dead Load (kN/m)
Tiles	23	= 0.03*23*0.54	0.373
Mortar	22	= 0.03*22*0.54	0.356
Sand	17	= 0.07*17*0.54	0.643
Topping	25	= 0.08*25*0.54	1.08
RC Rib	25	=0.27*25*0.14	0.945
Block	10	=0.27*10*0.4	1.08
Plaster	22	=0.03*22*0.54	0.356
Partitions		=2.76*0.54	1.49
∴ Dead Load for rib =6.32Kn/m / Rib			

Live lood = 5*0.54= 2.7KN/m/Rib

4.5 Design of Toppin:

Design of Topping for Ribbed Slab:
When designing the topp part of slab (topping) take a strip with a width of one meter to calculate the load on topping. Where the two ends of this strip are considered fixed to resist moment (Fixed Support).

Table (4-2) Calculation of the total dead load for topping.

1	**Tile**	**0.03*23*1= 0.69 KN/m**
2	**mortar**	**0.03*22*1= 0.66 KN/m**
3	**Coarse sand**	**0.07*17*1= 1.19 KN/m**
4	**topping**	**0.08*25*1 = 2.0 KN/m**
5	**Interior partitions**	**2.76 *1 =2.76 KN/m**
Sum		**7.3 KN/m**

W_u = 1.2 DL + 1.6 LL

= 1.2 * 7.3+ 1.6 * 5 = 16.76 KN/m^2. (Total Factored Load)

$M_u = \frac{W_u * l^2}{12} = \frac{16.75\times0.4^2}{12}$ = **0.22334 kN.m**

- Vu = $\frac{W_u\times L}{2} = \frac{16.75\times0.4}{2}$ = **3.35 kN**
- Mu = $\frac{W_u\times L^2}{12} = \frac{16.75\times0.4^2}{12}$ = **0.22334 kN.m**

Ø M_n≥ M_u, **where** Ø=0.55 (for plain concrete)

$Mn=0.42\lambda\sqrt{fc'}\, S_m$

Where S_m for rectangular section of the slab:

$$S_m = \frac{b\,h^2}{6} = \frac{1000\times80^2}{6} = 1066666.67\text{mm}^3$$

$M_n = 0.42\,\lambda\sqrt{fc'}\,S_m = 0.42 \times 1 \times \sqrt{24} \times 1066666.67 \times 10^{-6} = 2.19$ kN.m

Ø M_n = 0.55 × 2.19 = 1.207 KN.m >> M_u= 0.22334 kN.m

N0 reinforcement is required by analysis.According to ACI 10.5.4, provid As,min for slabs as shrinkage and temperature reinforcement.

According to ACI 7.12.2.1, $\rho\ shrinkage = 0.0018$

$A_s = \rho bh = 0.0018 \times 1000 \times 80 = 144\ mm^2 \quad for\ 1m\ strip$

Try bars Ø8 with A_s = 50.27mm$^{2.}$

Bar numbers n=$\left(\frac{As}{As,Ø8}\right)$= $\left(\frac{144}{50.27}\right)$=2.87.

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

Choosing (S) is the smallest of:

1. 3h = 3 × 80 = **240 mm** >>> Controlled **ACI (10.5.4)**
2. 450mm.
3. S = $380\left(\frac{280}{f_s}\right) - 2.5C_c = 380\left(\frac{280}{\frac{2}{3}420}\right) - 2.5\ .20 = 330\text{mm}$ **ACI (10.6.4)**
4. S ≤ 300 $\left(\frac{\mathbf{280}}{\mathbf{f_s}}\right)$ = 300 mm

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

4.6 Design of Rib 1

Material: -
concrete B300 **Fc' = 24 N/mm^2**
Reinforcement Steel **fy = 420 N/mm^2**

Section: -
b =14cm **b_f=54 cm**
h =35cm **T_f=8 cm**

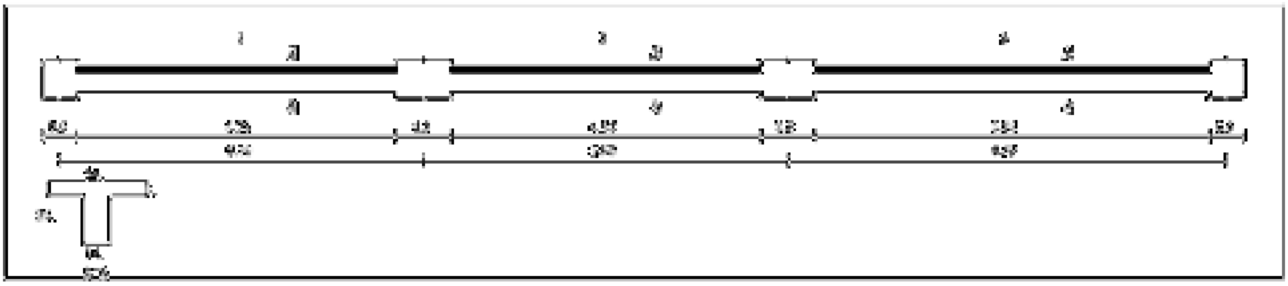

Fig. (4-2) rib geometry

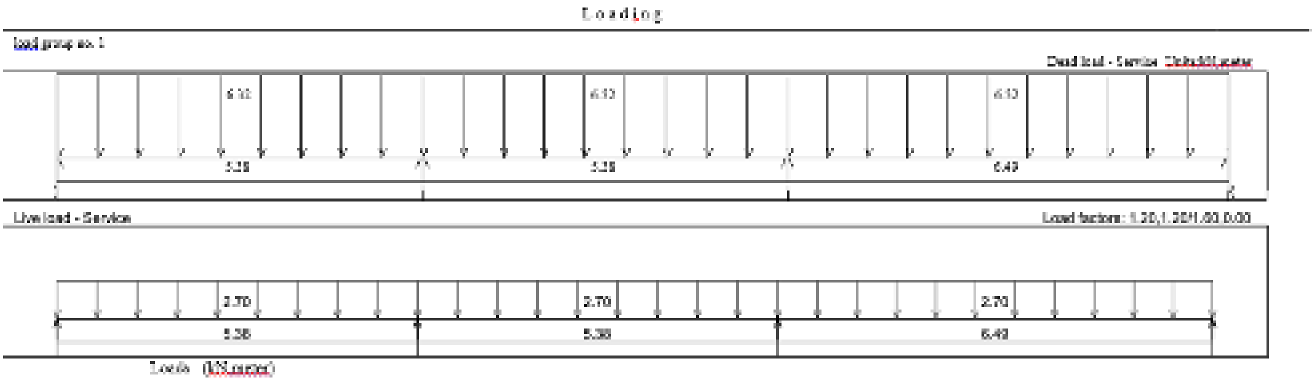

Fig. (4-3) loading of rib

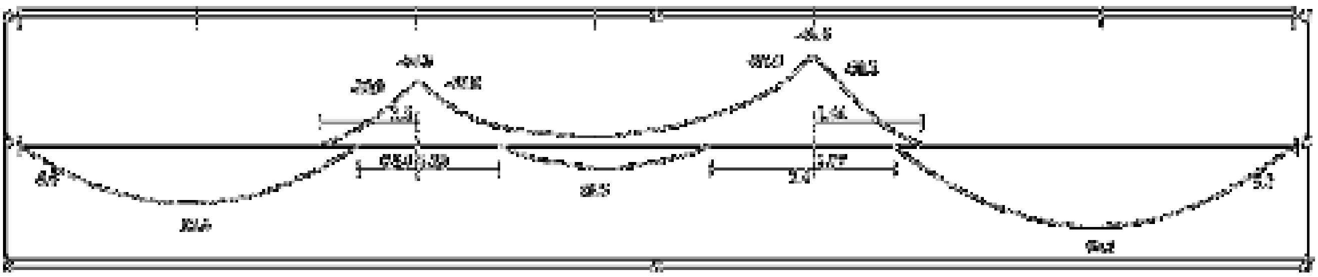

Fig (4-4): Moment Envelop of rib (1)

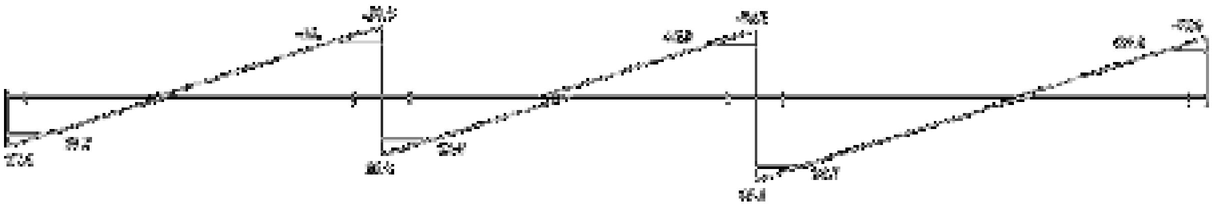

Fig (4-5): Shear Envelop of rib (1)

Design of Positive Moment for Rib

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

$= 350 - 20 - 10 - \frac{12}{2} = 314$ mm.

→$M_{u\ max}$ = 43.8KN.m

$be \leq$ Distance center to center between ribs = 540 mm………… Controlled.

≤ Span/4 = 6490/4 = 1622.5 mm.

≤ (16* t_f) + b_w =(16* 80) +140 =1420 mm.

→b_E= 540 mm.

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

$$= 0.85 * 24 * 0.54 * 0.08 * \left(0.314 - \frac{0.08}{2}\right) * 10^3 = 241.47 KN.m$$

ϕM_{nf} = 0.9 * 241.47 = 217.32 KN.m

→ϕM_{nf} =217.32> $M_{u\ max}$= 43.8 KN.m.

∴ **DESIGN AS RECTANGULAR SECTION**.

Maximum positive moment $Mu^{(+)}$ = **43.8 KN.m**

M_n = Mu /ϕ =43.8/ 0.9 = 48.67KN.m

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

$$R_n = \frac{M_n}{b*d^2} = \frac{48.67*10^6}{540*(314)^2} = 0.914\text{MPa}$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.914*20.58}{420}}\right) = 0.00223$$

→$A_s = \rho$ * b *d = 0.00223* 540 * 314= 377.77mm^2.

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

$= \frac{\sqrt{24}}{4*420} * 140 * 314 \ \geq \ \frac{1.4}{420} * 140 * 314$

= 128.2 mm^2<146.53 mm^2 …………. Larger value is control.

→As_{min} = 146.53 mm^2<As_{req} = 377.77 mm^2.

∴ As = 377.77 mm^2.

2 Φ16 =402.1 mm^2>As_{req} = 377.77mm^2 . OK.

∴ Use 2 Φ16

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

Tension = Compression

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

402.1* 420 = 0.85 * 24 * 140 * a

a = 59.13 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{59.13}{0.85}$ = 69.57mm.

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

$= \frac{314-69.57}{69.57} * 0.003$ = 0.0105> 0.005 ∴ ϕ =0.9 … OK!

Design of Negative Moment for Rib

Maximum negative moment $Mu^{(-)}$ = 34.8KN.m

M_n = Mu /ϕ =34.8/ 0.9 = 38.67 KN.m

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

$R_n = \frac{M_n}{b*d^2} = \frac{38.67*10^6}{140*(314)^2}$ = 2.8MPa

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*2.8*20.58}{420}}\right)$= 0.0072

→A_s = ρ * b *d = 0.0072* 140 * 314= 316.512 mm^2.

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

$= \frac{\sqrt{24}}{4*420} * 140 * 314 \ \geq \ \frac{1.4}{420} * 140 * 314$

$= 128.2\ mm^2 < 146.53\ mm^2$ ………… Larger value is control.

→ $As_{req} = 316.512\ mm^2 \geq As_{min} = 146.53\ mm^2$.

∴ $As = 316.512\ mm^2$.

$2\ \Phi 16 = 402.1\ mm^2 > As_{req} = 316.512 mm^2$. OK.

∴ Use 2 Φ16

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

Tension = Compression

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

$402.1 * 420 = 0.85 * 24 * 140 * a$

a = 59.13 mm.

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

$c = \frac{a}{\beta_1} = \frac{59.13}{0.85} = 69.57$mm.

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

$= \frac{314-69.57}{69.57} * 0.003 = 0.0105 > 0.005$ ∴ ϕ =0.9 … OK!

Design of shear of rib (RIB 1):

1) Vu = 37.7 KN.

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

$= 1.1 * \frac{\sqrt{24}}{6} * 0.14 * 0.314 * 10^3 = 39.36$ KN.

$\phi V_c = 0.75 * 39.36 = 29.52$ KN.

→Check for Cases: -

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

$37.7 \leq \frac{29.52}{2} = 14.76$

∴ Case (1) is NOT satisfied

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

$14.76 \leq 37.7 \leq 29.52$

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

Vs = $\frac{V_u}{\phi} - Vc = 10.9$

Vs max = $\frac{2}{3} * \sqrt{f_c'}$ *** d * b_w** = $\frac{2}{3} * \sqrt{24}$ *** 140 * 314***10^{-3}**= 143.11**

Vs´ = $\frac{\text{Vs max}}{2}$ **=71.56**

Vs min=$\frac{1}{16} * \sqrt{f_c'}$ * b_w* **d** =13.42

Vs min=$\frac{1}{3}$* b_w* **d** = 14.61 ....**Control.**

<u>Try 2Φ8: -</u>

$\frac{100.5*420*314}{S}$ = 14.61*10^3 → S = 907.18 mm.

S ≤$\frac{d}{2}$ = $\frac{314}{2}$ = 157 mm. … **Control**

≤ 600 mm.

∴ Use 2Φ8 @ 15 Cm

4.7 Design of Beam 54

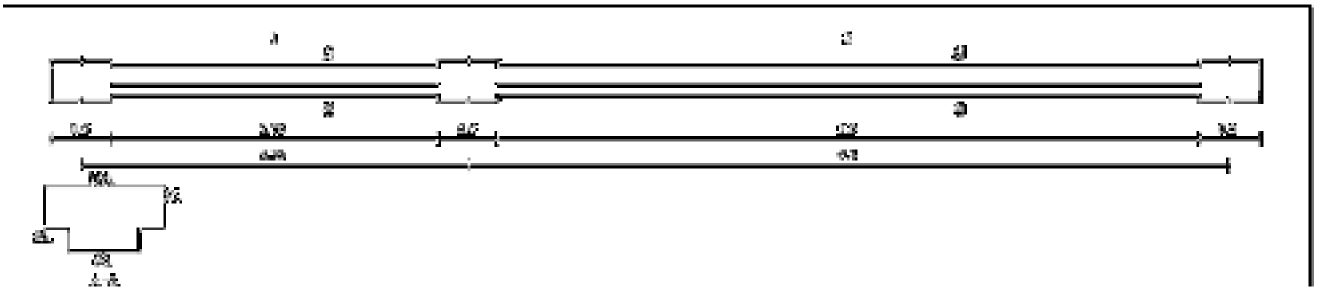

Fig (4-6): Beam Geometry.

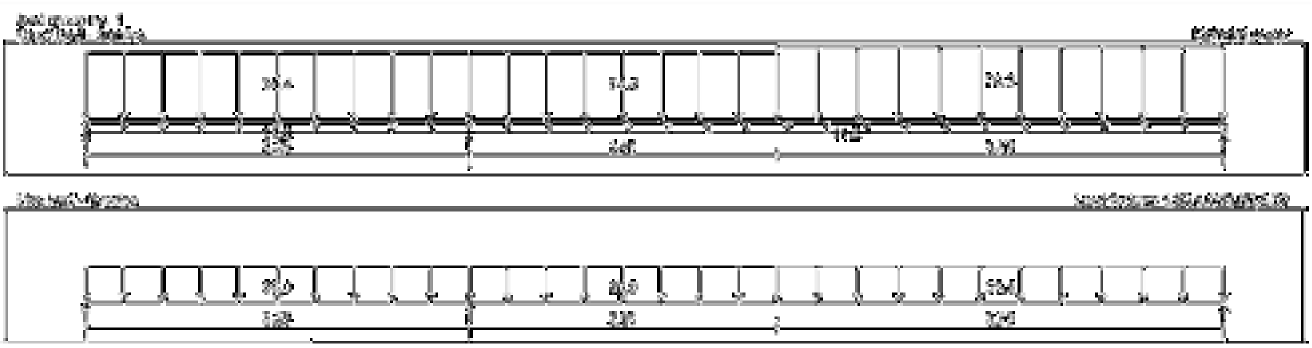

Fig (4-7): Load of Beam

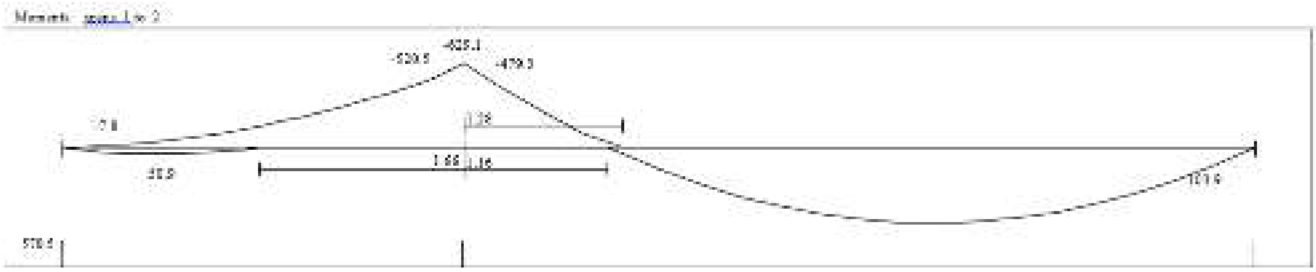

Fig (4-8): Moment Envelop for Beam

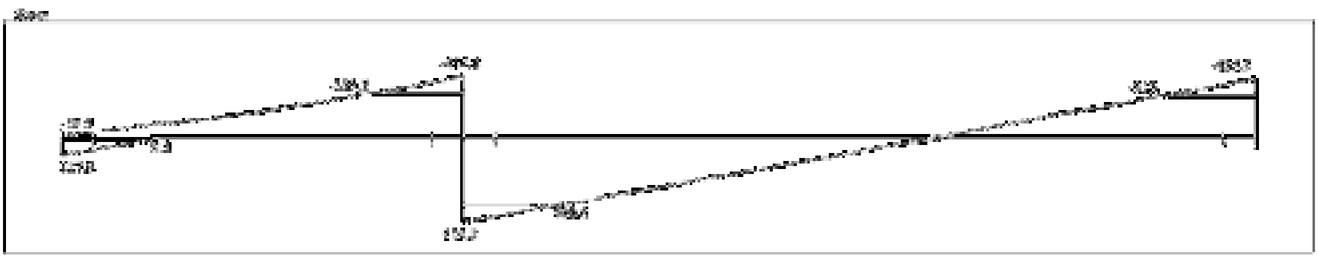

Fig (4-9): Shear Envelop for Beam

→Mu_{max} =570.5 KN.m

Bw =60 Cm.   H=55 Cm.

BE = 100 Cm.   Tf =35 Cm.

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

=550 – 40 – 10 – $\frac{18}{2}$ =491mm

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

$= 0.85 * 24 * 1 * 0.6 * \left(0.491 - \frac{0.6}{2}\right) * 10^3 = 2337.84 KN.m$

ϕM_{nf} = 0.9 * 2337.84 = 2104.056 KN.m

→ϕM_{nf} =2104.056> $M_{u\,max}$= 570.5 KN.m.

Design of positive moment

$Mu^{(+)}$ = **570.5 KN.m**

Mn = Mu /ϕ= 570.5/ 0.9 =633.89 KN.m .

→m=20.58

$R_n = \frac{M_n}{b*d^2} = \frac{570.5*10^6}{1000*(491)^2}$ =2.37 MPa

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

$\frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*2.37*20.58}{420}}\right)$=0.006

$A_s = \rho$ * b *d =0.00.6*1000*491= 2949.91 mm^2

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

$\frac{\sqrt{24}}{4 * 420} * 600 * 491 \;\; \geq \; \frac{1.4}{420} * 600 * 491$

=859.1mm^2<981.99mm^2 …. Larger value is CONTROL

As= 2949.91 mm^2

Use Φ22…. As=380.1mm^2

#of bars= (2949.91/380.1) =9

∴ **Use 9 Φ22…As=3421.2** >2949.91mm^2

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

Tension = Compression

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

3421.2* 420 = 0.85 * 24 * 1000 * a

a = 70.44mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{70.44}{0.85}$ = 82.86 mm.

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

$= \frac{491-82.86}{82.86}$ * 0.003 = 0.0147> 0.005 ∴ ф =0.9 … OK!

Design of negative moment

Mu (-) = **520.5 KN.m**

Mn = Mu /ф= 520.5/ 0.9 =578.33 KN.m .

→**m=20.58**

$R_n = \frac{M_n}{b*d^2} = \frac{578.33*10^6}{600*(491)^2}$ =3.99MPa

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

$\frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*3.99*20.58}{420}}\right)$=0.01069

$A_s = \rho$ * b *d =0.01069*600*491= 3151.29 mm^2

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

$\frac{\sqrt{24}}{4*420} * 600 * 491 \;\; \geq \; \frac{1.4}{420} * 600 * 491$

=859.1mm^2<982mm^2 …. Larger value is CONTROL

As= 3151.29 mm^2

Use Φ22…. As=380.1mm^2

#of bars= (3151.29/380.1) =9

∴ **Use 9Φ22…As=3421.2** > 3151.29mm^2

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

Tension = Compression

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

3421.2* 420 = 0.85 * 24 * 1000 * a

a = 70.44mm.

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

$c = \frac{a}{\beta_1} = \frac{70.44}{0.85} = 82.86$ mm.

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

$= \frac{491-82.86}{82.86} * 0.003 = 0.0147 > 0.005$ ∴ ϕ =0.9 … OK!

Design of shear for Beam

1) Vu = 500.4 KN .

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

$= 0.75 * \frac{\sqrt{24}}{6} * 600 * 491 * 10^{-3} = 180.4$KN.

\→ **Check For Cases:-**

1- Case1 :

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

$500.4 \leq \frac{180.4}{2} = 90.2$

∴ **Case (1) is NOT satisfied**

2- Case 2 :

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

45.1 <500.4≤90.2

∴ **Case (2) is NOT satisfied**

3- Case 3 : $\phi V_c < V_u \leq \phi V_c + \phi V_{s\,min}$

$\phi V_{s\,min} \geq \frac{\phi}{16}\sqrt{f_c'} * b_w * d = \frac{0.75}{16}\sqrt{24} * 0.6 * 0.491 * 10^3 = 67.65$KN.

$\geq \frac{\phi}{3} * b_w * d = \frac{0.75}{3} * 0.6 * 0.491 * 10^3 = 73.65$KN …. CONTROL.

∴$\phi V_{s\,min} = 73.65$ KN.

$\phi V_c + \phi V_{s\,min} = 180.4 + 73.65 = 254.05$ KN.

$\phi V_c < V_u \leq \phi V_c + \phi V_{s\,min}$

73.65<500.4≤ 254.05 OK

∴ **Case (3) is NOT satisfied**

4- <u>Case 4 :</u> $\phi V_c + \phi Vs_{min} < V_u \leq \phi V_c + \phi Vs`$

$\phi Vs` = \frac{\phi}{3}\sqrt{f_c'} * b_w * d$

$= \frac{0.75}{3} * \sqrt{24} * 0.6 * 0.491 * 10^3$

$= 360.8$

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

254.05 < 500.4 ≤ 541.2 OK

∴ Case (4) is satisfied.

$\rightarrow (\frac{Av}{S}) = \frac{Vs}{(fy_t * d)}$.

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

$Vc = \frac{180.4}{0.75} = 240.5KN$

$Vs = (\frac{500.4}{0.75} - 240.5) = 426.7KN.$

<u>Try 4Φ10</u> =4* 78.5 = 314 mm^2.

$\frac{4*78.5*}{S} = \frac{426.7 * 10^{-3}}{(420 * 491)} \rightarrow$ s = 151.7mm…. CONTROL

$s \leq \frac{d}{2} = \frac{491}{2} = 245.5$ mm ≤ 600 mm. **∴ Use Φ10 @ 15Cm 4sssL.**

4.8 Design of two way ribbed slab

1. **Approximate method:**

Approximate value of minimum(h) according to ACI

Minimum (h) ≥ (Maximum clear perimeter/180)

Minimum (h) ≥ (2*4.72+2*5.62)/180=11.48kc cm

Select (h=35 cm) > minimum (h); 8cm Topping+27cm Block

2. **Accurate method:**

$$\text{I for beam} = \frac{b * h^3}{12}$$

$$\text{I for beam (35\&36)} = \frac{80 * 50^3}{12}$$

$=833333.33\ cm^4$

$$\text{I for beam(37)} = \frac{50 * 35^3}{12}$$

$=178645.83\ cm^4$

$$\text{I for beam(20)} = \frac{80 * 35^3}{12}$$

$=285833.33\ cm^4$

The moment of inertia for the ribbed slab:

Be =54 cm was defined in one way ribbed slab

$$yc = \frac{40 * 8 * 4 + 35 * 14 * 17.5}{40 * 8 + 35 * 14}$$

=12.17 cm

$$\text{I for rib} = \frac{54 * 12.17^3}{3} - \frac{40 * 4.17^3}{3} + \frac{14 * 22.83^3}{3}$$

$=87007.51\ cm^4$

Slab section for exterior beam

Short direction: L=4.72 m =472cm

$$Is = \frac{Irib * (\frac{1}{2}L + bw)}{bf}$$

$$Is = \frac{87007.51 * (\frac{472}{2} + 80)}{54}$$

=509155.05cm^4

Long direction L=5.62m=562 cm

$$Is = \frac{87007.51 * (\frac{562}{2} + 80)}{54}$$

581661.31 cm^4 =

Slab section for interior beam

Short direction l_{right}= 4.72 l_{left} =0.75m

$$Is = \frac{87007.51 * (75 + \frac{472}{2} + 50)}{54}$$

=581661.3

Long direction l_{left}= 5.62m l_{right} = 0.75m

$$Is = \frac{87007.51 * (\frac{562}{2} + 75 + 80)}{54}$$

=702505.1cm^4

$$\alpha = \frac{Ib}{Is}$$

α1=833333.33/702505.1=1.19

α2=178645.83 /509155.05=0.35

α3=833333.33/581661.3=1.43

α4=285833.33 /581661.3 =0.49

αfm=(1.19+0.35+1.43+0.49)/4

= 0.865 <2.0 the minimum slab thickness will be :

$$h = \frac{\ln (0.8 + \frac{fy}{1400})}{36 + 5\beta(\alpha fm - 0.2)}$$

$$h = \frac{5620\,(0.8 + \frac{420}{1400})}{36 + 5 * 1.19(0.865 - 0.2)}$$

=154.7mm>125mm

β=5.62/4.72=1.19

First trial thickness h=350mm >154.7 mm_ok

Take slab thickness h_{slab} 350mm ,80mm topping ,270mm concrete block

- **Load calculation:**

Table(4-3) Dead Load Calculations For Two Way Ribbed Slab

Material	Quality Density $KN/\ m^3$	$W = \gamma \cdot V$ KN
Tiles	23	23 × 0.03 × 0.54 × 0.54 = 0.201
mortar	22	22 × 0.03 × 0.54 × 0.54 = 0.1925
Sand	17	17× 0.07 × 0.54 × 0.54 = 0.347
Reinforced Concrete Topping	25	25 × 0.08 × 0.54 × 0.54 = 0.583
Reinforced Concrete Rib	25	25 × 0.27 × 0.14 × (0.54 + 0.4) = 0.888
Concrete Block	10	10 × 0.27 × 0.4 × 0.4 = 0.432
Plaster	22	22 × 0.03 × 0.54 × 0.54 = 0.1925
Partitions 2.76 $KN/\ m^2$		2.76 × 0.54 × 0.54 = 0.805
Total Dead Load, KN		3.64

$$DL = \frac{3.64}{0.54 \times 0.54} = 12.48 \text{ KN/m2}$$

$w_D = 1.2 \cdot 12.48 = 14.98\ KN/m^2$

Live Load of slab:

$LL = 5\ KN/m^2$

$w_L = 1.6 \cdot 5 = 8\ KN/m^2$

$w = 14.98 + 8 = 22.98\ KN/m^2$

- **Moments calculations:**

$M_a = C_a w l_a^2$ and $M_b = C_b w l_b^2$

La/Lb = 0.85

- **Design of bending moment:**

Ma,pos ,DL=0.052*14.98*5.97^2
= 27.76 KN.m/m

Mb,pos ,DL=0.025*14.98*6.87^2
= 17.67 KN.m/m

Ma,pos,LL=0.052*8*5.97^2
=14.83 KN.m/m

Mb,pos,LL=0.025*8*6.87^2
=9.44 KN.m/m

Ma,pos =27.76+14.83=42.58 KN.m/m
Mb,pos =17.67+9.44=27.1 KN.m/m
Ma,neg =1/3*42.58=14.19 KN.m/m
Mb,neg =1/3*27.1=9.03 KN.m/m

- **Design of positive moments:-**

Mu=42.58 KN.m
ØMn =Mu
Mn=42.58/0.9=47.31 KN.m

Assume bar diameter Ø16 for main reinforcement
d=350-20-8-16/2=314mm
Rn=Mn/(b*d^2)

$=47.31/(540*314^2)$

=0.89 Mpa

m=fy/(0.85 fc)

=(420/.85*24)

=20.58

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

$$= \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.89*20.58}{420}}\right)$$

=0.002164

As=0.002164*540*314=366.92 mm2

- **Check of As min:**

As,min= 0.25*(√fc'/ fy)*bw*d ≥ 1.4/fy *bw*d

$128.19<146.53\ mm^2$

As min = 146.53 mm2 < As req = 366.92 mm2

∴As = 366.92 mm2 …. control

2Φ18 = 508.9 mm2 > Asreq = 366.92mm2 OK

∴ **Use 2 Φ18**

- Check for strain:

($\varepsilon_s \geq 0.005$)

Tension = Compression

As * fy = 0.85 * fc' * bw * a

508.9 * 420 = 0.85 * 24 * 540 * a

a = 19.4 mm

fc' = 24 MPa< 28 MPa→ β = 0.85

c=a/β = 19.4/0.85 = 22.82 mm

ε_s=(d-c)/c * 0.003

∴ ϕ =0.9 0.0381 > 0.005

Ok

- **Design of negative moments:-**

Mu=14.19 KN.m

Mn=$\frac{Mu}{\emptyset}$

=14.19/0.9=15.76 KN.m

Assume bar diameter Ø16 for main reinforcement

d=350-20-8-16/2=314 mm.

Rn=$\frac{M_n}{b*d^2}$

=15.76*10^6/(140*$314^{2)}$

=1.14 Mpa

`

m=420/(0.85*24)=20.58

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

$$= \frac{1}{20.58}(1 - \sqrt{1 - \frac{2*1.14*20.58}{420}})$$

=0.0028

As=0.0061*140*314=123.10mm^2

As,min= 0.25*(√fc'/ fy)*bw*d ≥ 1.4/fy *bw*d

128.19<146.53 mm^2

As min = 146.53 mm2 > As req = 123.10mm2

∴ As = 146.53 mm2 control

2Φ12 = 226.2 mm2 > Asreq = 146.53mm2 OK

∴ **Use 2 Φ12**

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

Tension = Compression

As * fy = 0.85 * fc' * bw * a

226.2* 420 = 0.85 * 24 * 140 * a

a = 33.26 m

fc'= 24 MPa< 28 MPa→ β = 0.85

$c = a/\beta$ = 33.26/0.85 = 39.13 mm

εs =(d-c)/c * 0.003

Ok 0.02107 > 0.005

∴ ϕ =0.9

- **Design of shear:**

W_a= 0.67

The total load on the panel being =(5.97*6.87*22.98=942.499 KN

The load per rib at the face of short beam is (0.67*942.499*0.54)/(2*6.86)=24.85KN

V_{ud} =Vu_{face}-(Wu*bf*d)=24.85-(22.98*0.54*0.314)=20.95 KN

The maximum shear force at the distance d from the face of support, Vu = 346 KN

Vc = 1.1(√fc' /6 * bw * d)

= 1.1(√24/6 * 140 * 313) = 39.35 KN

ϕVc = 0.75 * 39.35= 29.5 KN

Case1: Vu ≤ (ϕVc)/2

20.95 < 29.5/2 =14.75 ∴ Case (1) is not satisfied

Case2: Vu ≤ (ϕVc)

20.95 < 29.5 ∴ Case (2) is satisfied

∴minimum shear reinforcement is required

$Vs_{min} \geq \frac{1}{16}\sqrt{f_c'} * b_w * d = \frac{1}{16}\sqrt{24} * 140 * 0.313 * 10^3 = 13.42$ KN.

$\geq \frac{1}{3} * b_w * d = \frac{1}{3} * 140 * 0.313 * 10^3 = 14.61$ KN …. CONTROL.

∴Vs_{min} = 14.61 KN.

<u>Try 2Φ8: -</u>

$\frac{100.5*420*313}{S} = 14.61*10^3 \rightarrow S = 904.3$ mm.

$S \leq \frac{d}{2} = \frac{313}{2} = 156.5$ mm. … **Control**

≤ 600 mm. ∴ **Use 2Φ8 @ 15 Cm**

4.9 DESIGN OF STAIRS

In this section we will design the sitars (STAIR 1) , we have the dimensions from architectural plans , in figure – shown the dimensions of stair , we will design according to (ACI-Code-318M-11) , fig-- & fig—shown the structural system in stair (landing & flight) , the result of design :

Concrete B300 f_c'=24N/mm^2.

Reinforcement Steel f_y=420 N/mm^2.

Wall thickness=30 cm, Cover = 20mm.

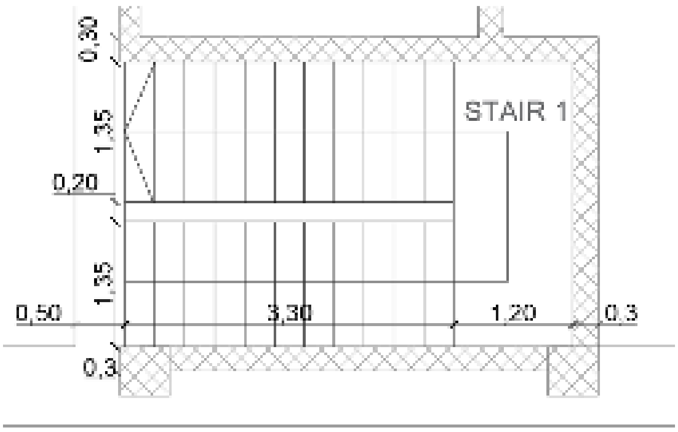

Fig. (4.10) plan of stair 1

1) Design of Flight.

- **Structural System.**

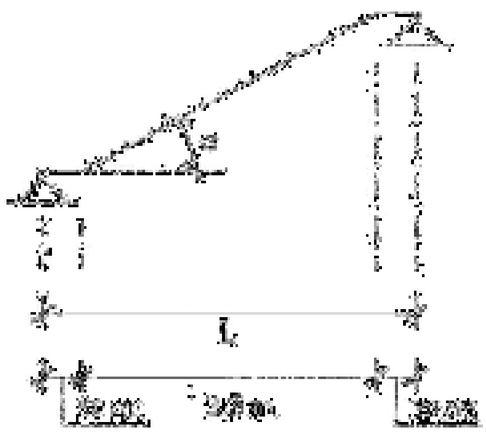

Fig. (4.11) structural system of flight

- **Limitation of deflection:**

$$h\ (min) = \frac{L}{20} = \frac{415}{20} = 20.75cm \Rightarrow \text{Select } h = 21\ cm.$$

$$\frac{400}{24} = 16.7\ cm \Rightarrow \text{Angle } (\alpha): \quad \tan(\alpha) = 16.7/27.5 \rightarrow \quad \alpha = 31.3°$$

- **Calculate Loads of The Flight.**

Table (4-4) the dead load acting on the flight

(KN/m) Load		Material
6.1	$0.21\times 25\times 1\times (\frac{1}{\cos 31.3})$	**Flight**
1.01	$0.04\times 23\times (\frac{33}{30})$	**Horizontal Tile**
0.38	$0.03\times 23\times (\frac{16.7}{30})$	**Vertical Tile**
0.66	$0.03\times 22\times 1$	**Horizontal Mortar**
0.37	$0.03\times 22\times (\frac{16.7}{30})$	**Vertical Mortar**
0.88	$0.03\times 25\times 1\times (\frac{1}{\cos 31.3})$	**Plaster**
2.09	$0.5\times 0.167\times 25$	**Triangle Concrete**
11.3	**Total**	

Dead Load = 11.1 kN/m & Live Load = 3kN/m

- Factored Load (qu).

$$q_u = 1.2 \times \text{Dead Load} + 1.6 \times \text{Live Load}$$
$$= 1.2 \times 11.3 + 1.6 \times 3$$
$$= 18.36\ kN/m.$$

- **Internal Forces of Flight.**
  - Shear Force Diagram.

→ Au = (qu/2) ×3.3 = (18.36/2) × 3.3= 30.3 kN.

Max. Vu of Flight = 30.3× cos 31.3 = 25.9 kN.

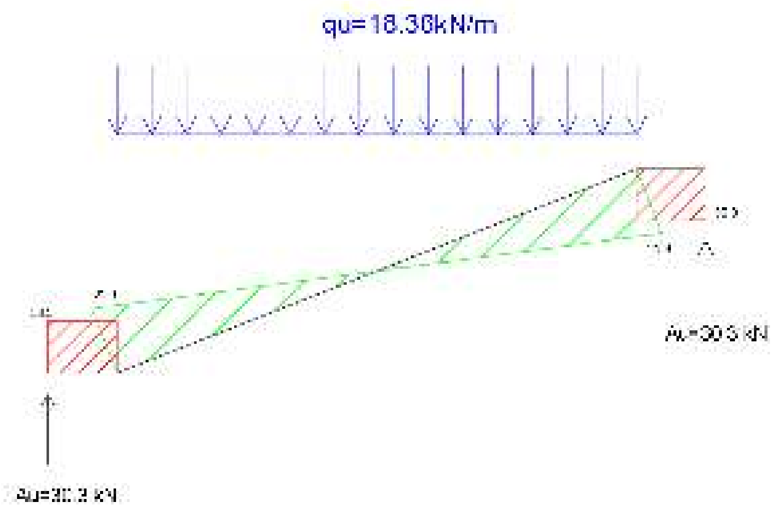

Fig. (4.12) shear forces acting on flight

- Bending Moment Diagram.

Max. Mu of Flight = 30.3×2.05 – 18.36×1.65×0.825 = 37.1 kN.m

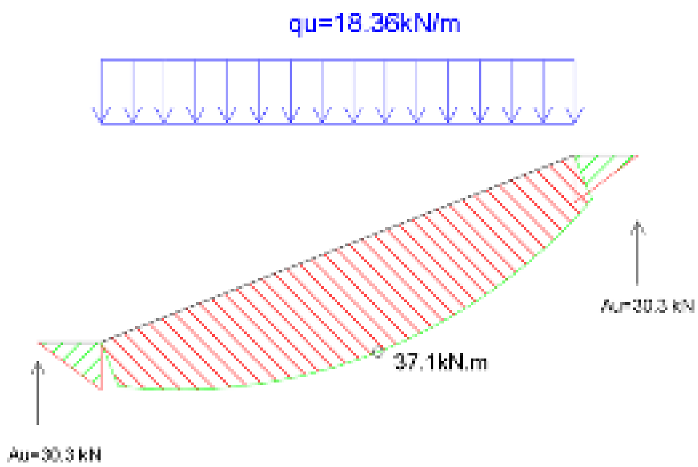

Fig. (4.13) moment acting on the flight

- **Design of Shear Force:**

d = 210– (20+0.5×12) = 184 mm

$$\emptyset \times Vc = 0.75 \times \frac{1}{6} \times \sqrt{fc'} \times b \times d = 0.75 \times \frac{1}{6} \times \sqrt{24} \times 1000 \times 184 = 112.6\ kN$$

$\emptyset \times Vc$ = 112.6 kN > Vu_{Max} = 25.6 kN

<u>So, No Shear Reinforcement is required.</u>

<u>So, (h=21 cm) is O.K</u>

- **Design of Bending Moment:**

Mu =37.1 KN.m

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{37.1\times10^6}{0.9\times1000\times184^2} = 1.22\ Mpa.$ $m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times1.22}{420}}\right) = 0.00299.$$

➔ $A_{s,\,req}$ = ρ.b.d = 0.00299×1000×184 = 550.4 mm^2.

- Check for $A_{s,\,min}$.

$A_{s,\,min}$ = 0.0018×b×h = 0.0018×1000×210 = 378 mm^2

➔ $A_{s,\,req}$ = 550.4 mm^2> $A_{s,\,min}$ = 378 mm^2

Use 4Ø14 Bottom with $A_{s,\,provided}$ = 616mm² > $A_{s,\,required}$ = 550.4 mm². → Ok

- Check for strain:

$a = \frac{A_s.f_y}{0.85 b\ f_c'} = \frac{616\times420}{0.85\times1000\times24} = 12.7\ mm$ $c = \frac{a}{\mathcal{B}_1} = \frac{12.7}{0.85} = 14.9\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{184-14.9}{14.9}\right) = 0.034 \geq 0.005 \rightarrow 0k$$

2) Design of Landing.

- **Structural System.**

Landing slab should be divided into two slab regions

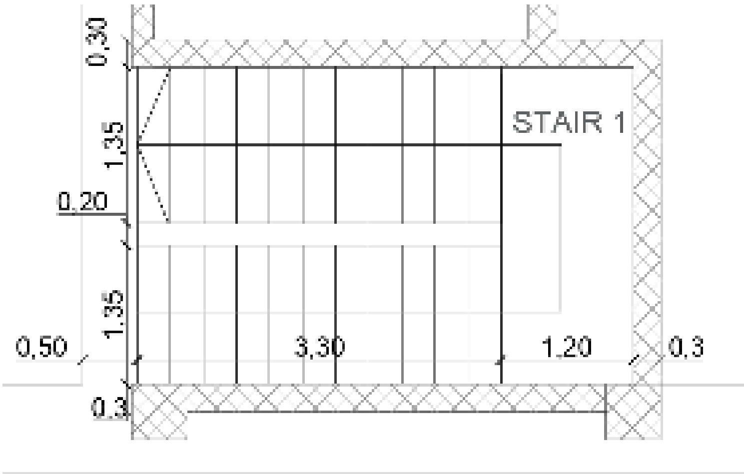

Fig. (4.14) plan of stair 1

- **Limitation of Deflection.**

$$h\ (min) = \frac{L}{20} = \frac{400}{20} = 16\ cm \Rightarrow \text{Select } h = 21\ cm.$$

- **Calculate Loads of The Landing.**

Table (4-5) the dead load acting on landing

(KN/m^2) Load $\gamma \times t$	(cm) Thikness	Materials
5.25	21	**Slab**
0.88	4	**Tile**
0.44	2	**Mortar**
1.19	7	**Sand**
0.66	3	**Plaster**
8.42	**Total**	

Dead Load = 8.42 kN/m & Live Load = 3kN/m

- Factored Load (qu):

$$q_u = 1.2 \times \text{Dead Load} + 1.6 \times \text{Live Load}$$

$$= 1.2 \times 8.42 + 1.6 \times 3$$

$$= 14.9\ kN/m.$$

- **Design of The Flight.**

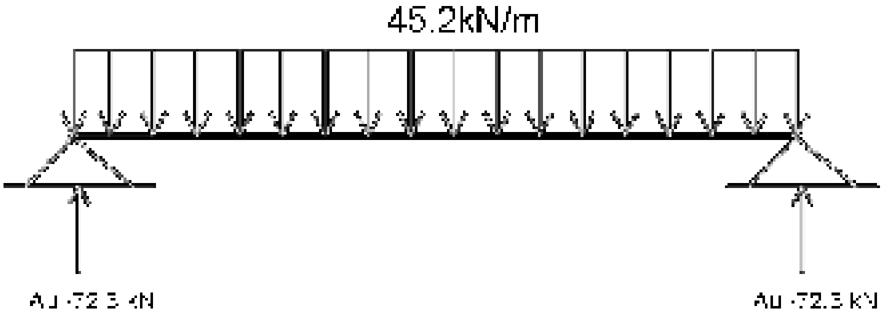

Fig. (4.15) loads and reactions

$$Vu = 72.3 - 45.2\times(0.15+0.184) = 57.2 \text{ kN}$$

$$Mu = \frac{qu\times L^2}{8} = \frac{45.2\times3.2^2}{8} = 57.9 \text{ kN.m}$$

- ## Design of Shear Force:

$$d = 210 - (20+0.5\times12) = 184 \text{ mm}$$

$$\emptyset\times Vc = 0.75\times\frac{1}{6}\times\sqrt{fc'}\times b\times d = 0.75\times\frac{1}{6}\times\sqrt{24}\times1000\times184 = 112.6\ kN$$

$$\emptyset\times Vc = 112.6 \text{ kN} \quad > \quad Vu_{Max} = 57.2 \text{ kN}$$

<u>So, No Shear Reinforcement is required.</u>

<u>So, (h=21) is O.K</u>

- ## Design of Bending Moment:

$$Mu = 57.9 \text{ KN.m}$$

$$R_n = \frac{M_u}{\emptyset bd^2} = \frac{57.9\times10^6}{0.9\times1000\times184^2} = 1.9\ Mpa. \qquad m = \frac{f_y}{0.85f_c'} = \frac{420}{0.85\times24} = 20.6$$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times1.9}{420}}\right) = 0.00476.$$

➔ $A_{s,\,req} = \rho.b.d = 0.00476\times1000\times184 = 876\ mm^2$.

- Check for $A_{s,\,min}$

$A_{s,\,min} = 0.0018\times b\times h = 0.0018\times1000\times210 = 378\ mm^2$

➔ $A_{s,\,req} = 876\ mm^2 > A_{s,\,min} = 378\ mm^2$

Use 5Ø16 Bottom with $A_{s,\,provided} = 1005\ mm^2 > A_{s,\,required} = 876\ mm^2$. → Ok

- Check for strain:

$$a = \frac{A_s.f_y}{0.85b\,f_c'} = \frac{1005\times420}{0.85\times1000\times24} = 20.7\ mm \qquad c = \frac{a}{\beta_1} = \frac{20.7}{0.85} = 24.3\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{184-34.3}{34.3}\right) = 0.02 \geq 0.005 \ \rightarrow \ 0k$$

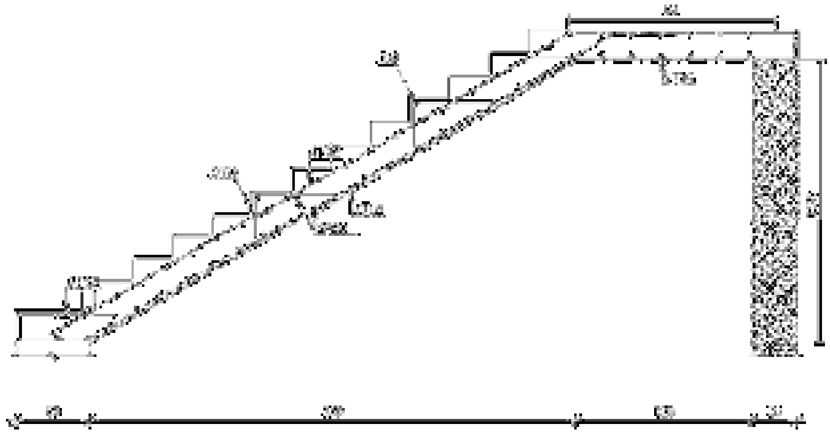

Fig. (4.16) section of stair shown the reinforcement

4.10 Design of Coulmn

In this section we will design column , and we will calculate the dimension of coulmn and ratio of steel needed to resist the loads on column , and we will design on (ACI-Code-318m-11):

Concrete B300 f_c'=24N/mm^2.

Reinforcement Steel f_y=420 N/mm^2.

$\varnothing_{Steel}$ = 20mm, $\varnothing_{Stirrups}$ = 10mm.

Cover = 40mm.

1) Load Calculation.

- **Service Load.**

  Dead Load = 1500 KN

  Live Load = 600 KN

- **Factored Load.**

  Pu = 1.2 ×1500+ 1.6×600= 2760 KN

2) Dimensions of Column.

We will design the column as a short column with rectangular shape with central load , and we suppose the minimum ratio of steel (pg=0.01)

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

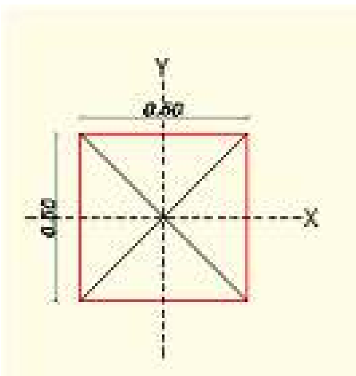

Fig. (4.17) Dimenstion of column (C3)

➔2760 = 0.65×0.8×Ag {0.85*24(1–0.01)+0.01*420}

➔ Ag= 217564.38 mm^2

h 500mm

b = 500 mm

3) Classification of Column Section.

- Check Slenderness Parameter.

$$\frac{K\,Lu}{R} \leq 34 - 12\frac{M1}{M2} \leq 40 \qquad \textbf{ACI (10.3.6.1)}$$

Where:

Lu: Actual unsupported (Unbraced) length.

K: effective length factor. According to **ACI 318 (10.10.6.3)** The effective length factor K, shall be permitted to be taken as 1.0.

R: radius of gyration = $\sqrt{\frac{I}{A}}$ ≈ 0.3 h (For rectangular section).

➔ Lu = 3.50 m   M1/M2 =1   K=1 for pinned release columns in braced frame.

- System about X-Axis.

$$\frac{K_x\,L_x}{R_x} = \frac{1.0 \times 3.5}{0.3 \times 0.5} = 23.33$$

System is braced ➔ $23.33 \leq^{?} 34 - 12(1) \leq 40 \rightarrow 23.33 > 22$

∴System is LONG about X

- System about Y-Axis.

$$\frac{K_x\,L_x}{R_x} = \frac{1.0 \times 3.5}{0.3 \times 0.5} = 23.33$$

System is braced ➔ $23.33 \leq^{?} 34 - 12(1) \leq 40 \rightarrow 23.33 > 22 < 40$

∴System is LONG about Y

Nominal axial strength column $P_n = P_{nx}$ in e_x direction (long)

Nominal axial strength column $P_n = P_{ny}$ in e_y direction (long)

4) Minimum Eccentricity (min e).

$$\min e = 15 + 0.03\,h$$

$$\min e = 15 + 0.03 \times 500 = 30\ mm$$

5) Factored Load.

$$Mu_x = \min e \times Pu = 0.030 \times 2760 = 82.8 \text{KN.m}$$

6) Magnification Factor ($\boldsymbol{\delta_{ns}}$).

$$\boldsymbol{\delta_{ns}} = \frac{\mathbf{C_m}}{\mathbf{1-(\frac{Pu}{0.75\times P_{cr}})}} \geq \mathbf{1.0\ \ and\ \ \leq 1.4}$$ **ACI (10.10.7.4)**

Where:

$$C_m = 0.6 + 0.4 * \left(\frac{M1}{M2}\right) \geq 0.4 \rightarrow C_m = 0.6 + 0.4 * \left(\frac{1}{1}\right) = 1.0$$

$$P_{cr} = \frac{\pi^2 \times (E \times I)}{(k \times L_u)^2} \quad , \quad E * I = \frac{0.4 * E_c * I_g}{1 + B_d}$$

$$B_d = \frac{1.2 \times P_D}{1.2 \times P_D + 1.6 \times P_L} \quad , \quad I_g = \frac{bh^3}{12} \quad , \quad E_c = 4750 \times \sqrt{fc'}$$

$$\rightarrow B_d = \frac{1.2 \times 1500}{2760} = 0.65 \quad , \quad E * I = \frac{0.4 \times 4750 \times \sqrt{24} \times 500 \times \frac{500^3}{12}}{1 + 0.65} = 29381.5 kN/m^2$$

$$\rightarrow P_{cr} = \frac{\pi^2 \times 29381.5}{(1 \times 3.5)^2} = 23672.14\ kN$$

$$\rightarrow \delta_{ns} = \frac{1.0}{1-(\frac{2760}{0.75 \times 23672.14})} = 1.18 \quad \geq 1.0\ \ and\ \ \leq 1.4$$

7) Design of Moment M_{nx}.

$$Mn_x = \delta_{ns} \times Mu = 1.18 \times 82.8 = 97.7 \text{ KN.m}$$

$$e_y = \delta_{ns} \times \min e = 1.18 \times 0.030 = 0.0354\ m$$

8) Interaction Diagram.

$$e_y = 0.0354\ m \quad , \quad h = 0.5\ m$$

$$\frac{e_y}{h} = \frac{0.0354}{0.5} = 0.0708$$

$$\gamma = \frac{d - d'}{h} = \frac{500 - 2 \times (40 + 10 + \frac{25}{2})}{500} = 0.75$$

$$\frac{\emptyset \times Pn}{Ag} = \frac{Pu}{Ag} \quad , \quad \frac{2760}{500 \times 500} \times 145 = 1.6\ Ksi$$

- Form Diagram A-9a ($\gamma = 0.6$)

$$\rho_g = min\rho_g = 0.01$$

- Form Diagram A-9b ($\gamma = 0.75$)

$$\rho_g = min\rho_g = 0.01$$

$$So, \ \ \rho_g = min\rho_g = 0.01$$

$$As_{req} = \rho \times Ag = 0.01 \times 500 \times 500 = 2500\ mm^2$$

Use 14 Ø16 with $A_{s,\ provided}$ = 2815.4mm^2 > $A_{s,\ required}$ = 2500 mm^2. → Ok

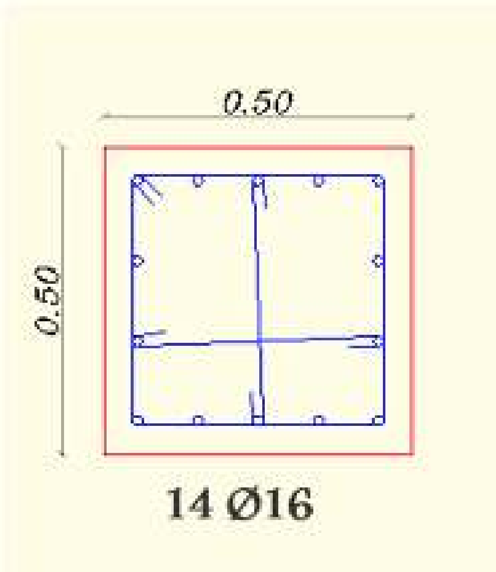

Fig. (4.18) (REINFORCMENT OF COULMN (C3)

4.11 Design of shear wall

In this section we will design shear wall (SW3) , we have the dimenstions from architectural plans , and we have the forces of earthquakes from E-tabs , we design according to (ASCE-7-16) and we have the result :

Concrete B300 f_c'=24N/mm^2.
Reinforcement Steel f_y=420 N/mm^2.
Wall thickness=30 cm, Cover = 20mm.
Lw=3.8m , hw=17.75m

1) Analysis.

$$Pu = 0 \rightarrow Nu = 0\,; \sum Fx = 0 \rightarrow Vu = 23.2\ KN$$

$$\sum Moment\ (Mu) = 409.2\ KN.m$$

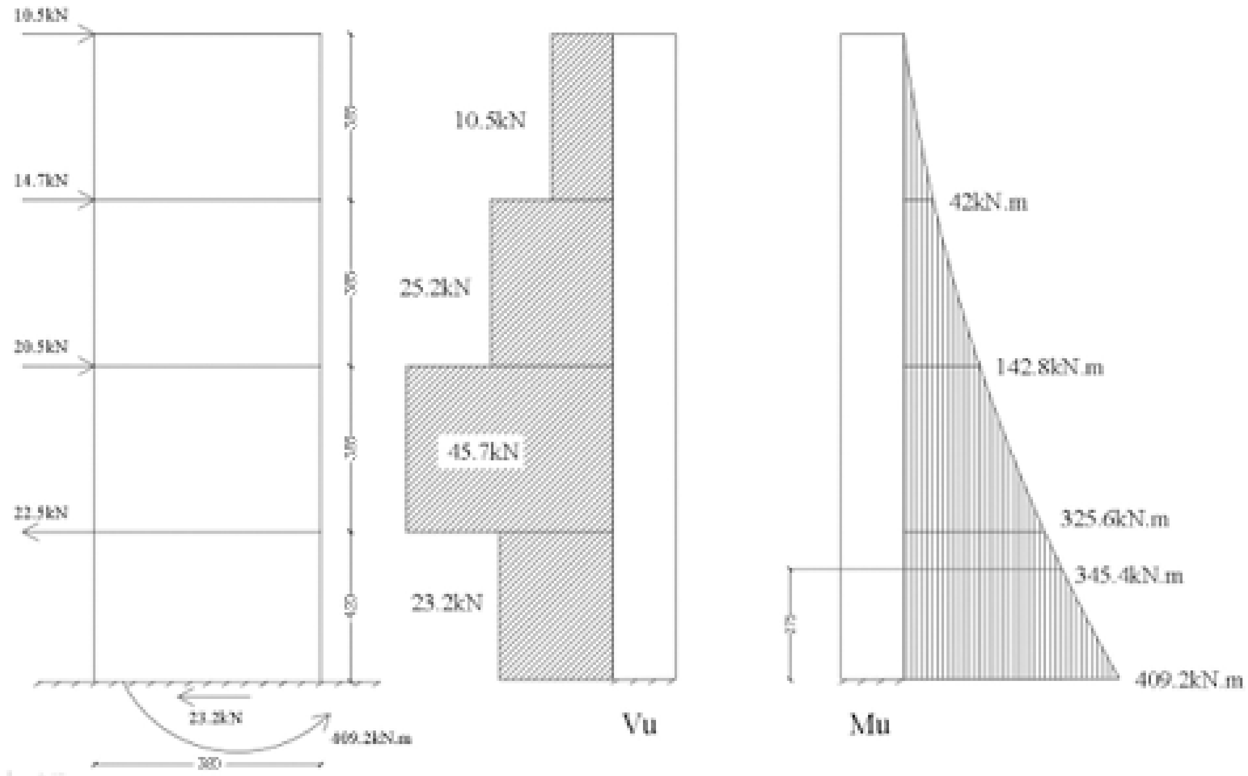

Fig. (4.19) forces of earthquakes , the shear & moment forces from e-tabs program

2) Determination of (Mu1).

Where Lw < hw Controlled section for (Mu =Lw/2) from the base of shear wall.

$$Lw/2 = 3.8/2 = 1.9\ m$$

$$\therefore Mu1 = 409.2 - 1.9 \times 23.2 = 365.12\ KN.m$$

3) Design.

Design as rectangular section with:

$Since\ \ Lw < hw \rightarrow d = 0.8 \times Lw = 0.8 \times 3.8 = 3.04\ m$

a. Design of Horizontal Reinforcement for Story (1).

Horizontal reinforcement to resist factored shear force Vu.

$$Vu = Vu_{max} = 23.2\ KN$$

❖ Vc=The smallest of:

1. $Vc = \frac{1}{6} \times \sqrt{fc'} \times b \times d = \frac{1}{6} \times \sqrt{24} \times 300 \times 3040 = 744.66\ KN$
2. $\mathrm{Vc} = \frac{1}{4} \times \sqrt{\mathrm{fc}'} \times \mathrm{b} \times \mathrm{d} + \frac{\mathrm{Nu \times d}}{4 \times \mathrm{Lw}} = \frac{1}{4} \times \sqrt{24} \times 300 \times 3040 + 0 = 1116.99\ \mathrm{KN}$
3. $\mathrm{Vc} = \left(0.5 \times \sqrt{\mathrm{fc}'} + \frac{\mathrm{Lw} \times \left(\sqrt{\mathrm{fc}'} + \left(\frac{2 \times \mathrm{Nu}}{\mathrm{Lw} \times \mathrm{h}}\right)\right)}{\left(\frac{\mathrm{Mu_1}}{\mathrm{Vu}}\right) - \left(\frac{\mathrm{Lw}}{2}\right)}\right) \times \frac{\mathrm{h \times d}}{10}$

$$= \left(0.5 \times \sqrt{24} + \frac{3.8 \times \left(\sqrt{24} + 0\right)}{\left(\frac{365.12}{23.2}\right) - \left(\frac{3.8}{2}\right)}\right) \times \frac{300 \times 3040}{10} = 122.67\ KN \ldots.Control$$

$$\therefore \emptyset \times Vc = 0.75 \times 122.67 = 92\ KN > Vu = 23.2\ KN$$

<u>So, Horizontal reinforcement is Not required.</u>

$$\left(\frac{\mathrm{Avh}}{s}\right)\mathrm{min} = 0.0025 * \mathrm{h} = 0.0025 * 300 = 0.75$$

$$\left(\frac{\mathrm{Avh}}{s}\right)_{req} = \left(\frac{\mathrm{Avh}}{s}\right)_{min} \rightarrow \frac{\mathrm{Avh}}{s} = 0.75 \ldots \mathrm{Controls}$$

- According to (ACI) - step (s) must not be greater than:

1. $S_{max} = \frac{Lw}{5} = \frac{3800}{5} = 760\ mm$
2. $S_{max} = 3 \times h = 3 \times 300 = 900\ mm$
3. $S_{max} = 450\ mm \ldots Controls$

Assume Ø12 steel ➔ $Avh = 2\ legs \times \frac{\pi \times 12^2}{4} = 226.19\ mm^2$

$$S_{req} = Avh/0.75 = 226.19/0.75 = 301.59\ mm$$

$$select\ S = 250\ mm < Smax = 450\ mm\ ok$$

Select Φ12@250mm at each side.

b. Design of uniform distributed vertical reinforcement for Story (1):

Vertical reinforcement to resist Nu and apart of Mu.

$$Avv = \left[0.0025 + 0.5\ (2.5 - hw/Lw) \times \left(\frac{Avh}{S_{horizontal} * h} - 0.0025\right)\right] \times h \times S_{vertical}$$

$$\frac{Avv}{s} = \left[0.0025 + 0.5 \times \left(2.5 - \frac{17.75}{3.8}\right) \times \left(\frac{226.19}{250 \times 300} - 0.0025\right)\right] \times 300 = 1.15$$

$$Where \rightarrow \left(2.5 - \frac{15.6}{5.5}\right) \leq 2.5$$

Select Ø12 2 layers ➔ $A_{vv} = 2 \times 113.09 = 226.19\ mm^2$

$$\frac{226.19}{S} = 1.15\ ,\ S\ req = 196.68mm$$

Select S = 200 mm

- According to (ACI) - step (s) must not be greater than:

1. $S_{max} = \frac{Lw}{3} = \frac{3800}{3} = 1266.67\ mm$
2. $S_{max} = 3 \times h = 3 * 300 = 900\ mm$
3. $S_{max} = 450\ mm \ldots Control$

S=200 mm < 450 mm …Ok

Select Φ12@200mm at each side

c. Check for Boundary Reinforcement.

Part of moment that resisted through (Avv):

$$Asv = 2 \times 113.09 \times \frac{3800}{200} = 4297.42\, mm^2$$

$$\frac{z}{Lw} = \frac{1}{2 + \left(\frac{0.85 * \beta * fc' * Lw * h}{Asv * fy}\right)} = \frac{1}{2 + \left(\frac{0.85 * 0.8 * 24 * 3800 * 300}{4297.42 * 420}\right)} = 0.081$$

$$Muv = 0.9 * \left(0.5 * Asv * fy * Lw * \left(1 - \frac{z}{2 * Lw}\right)\right)$$

$$= 0.9 * \left[0.5 * 4297.42 * 420 * 3800 * \left(1 - \frac{0.081}{2}\right)\right] = 2961.4\, KN.m$$

$$Muv = 2961.4 KN.m > Mu = 409.2 KN.m$$

Boundary steel is not required.

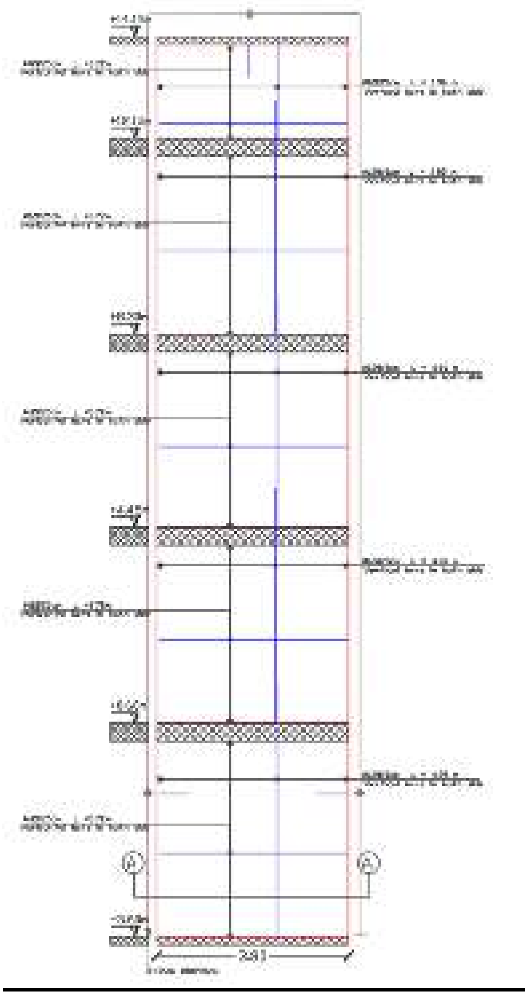

Fig. (4.20) reinfircment of shear wall (sw3)

4.12 Design of Basement Wall

In this section we will design basement wall , we have the dimenstions from architectural plans , and we have the properties of siol from testing laborety, in figure show the moment loads on the basement wall, we design according to (ACI-Code-318M-11) and we have the result :

Concrete B300 f_c'=24N/mm^2.

Reinforcement Steel f_y=420 N/mm^2.

Wall thickness=30 cm, Cover = 20mm.

γ_{soil}=18 KN/m^3 , $\emptyset_{soil}$=30.0^o , Wall Height =385 m.

1) System and loads

$$k_o = 1 - \sin\emptyset = 1 - \sin 30 = 0.5$$

$$e_o = k_o \times \gamma \times h = 0.5 \times 18 \times 4.20 = 37.8 KN/m^2$$

$$E_o = e_o \times \frac{h}{2} = 37.8 \times \frac{4.2}{2} = 79.38\ KN/m$$

$$k_o \times LL = 0.5 \times 10 = 5\ KN/m^2$$

$$5 \times 4.20 = 21\ KN/m$$

- **For (1m) strip**

$$Factored\ loads\ (qu) = 1.6 \times (37.8\ + 5)\ = 68.48\ KN/m$$

$$Factored\ loads\ (qu) = 1.6 \times k_o \times LL = 1.6 \times 5\ = 8\ KN/m$$

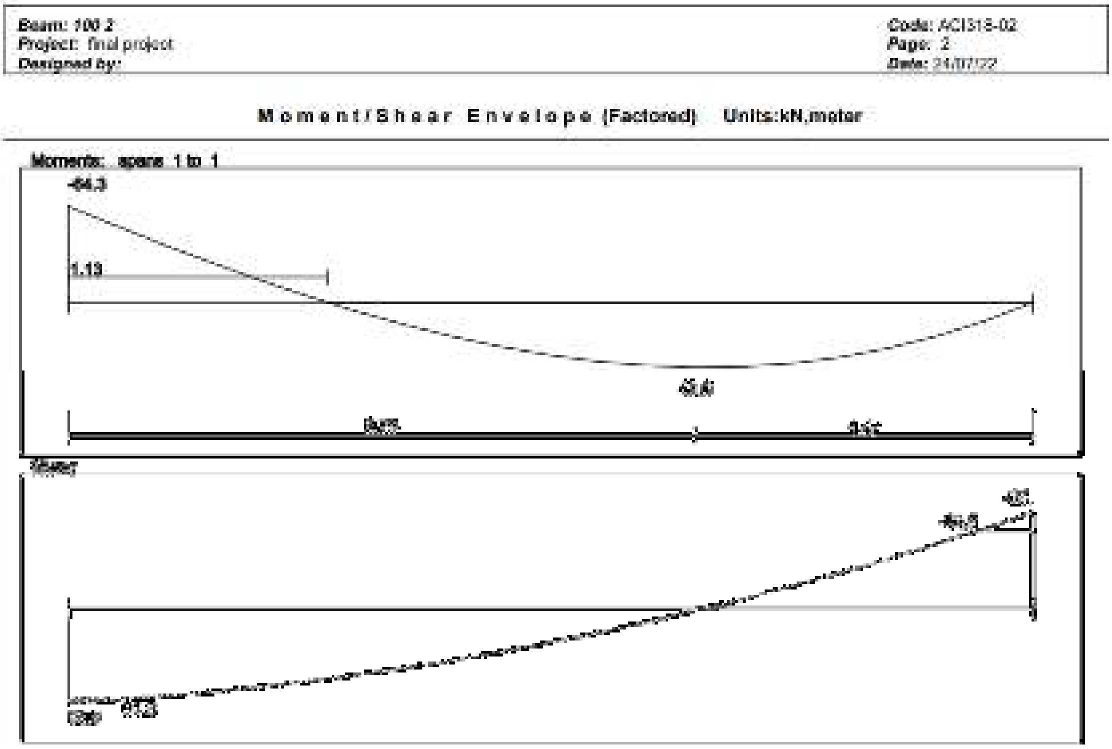

Fig. (4.21) the moments on the basement wall

2) Design of Shear Force.

$$d = 300 - 20 - 20 = 260\ mm$$

$$Vu_{max} = 65kN$$

$$\emptyset \times Vc = 0.75 \times \frac{1}{6} \times \sqrt{24} \times 1000 \times 260 = 159.22\ kN > Vu = 65kN$$

<u>∴h=30 cm is Ok</u>

3) Design of Bending Positive Moment.

Mu = +43.6 KN.m

$$Rn = \frac{Mn}{b \times d^2} = \frac{48.44 \times 10^6}{1000 \times 260^2} = 0.716MPa \qquad m = \frac{fy}{0.85 \times f_{c'}} = \frac{420}{0.85 \times 24} = 20.6$$

$$Mn = \frac{Mu}{\emptyset} = \frac{43.6}{0.9} = 48.44\ KN.m$$

$$\rho_{req} = \frac{1}{m} \times \left(1 - \left(\sqrt{1 - \frac{2 \times Kn \times m}{Fy}}\right)\right) = \frac{1}{20.6} \times \left(1 - \left(\sqrt{1 - \frac{2 \times 0.716 \times 20.6}{420}}\right)\right) = 0.00174$$

$$As_{req} = \rho_{req} \times b \times d = 0.00174 \times 100 \times 26 = 4.524\ cm^2$$

- Check for $A_{s\ min}$.

$$As_{min} = 0.0012 \times b \times h = 0.0012 \times 100 \times 30 = 3.6\ cm^2$$

$$As_{req} > As_{min} = 3.6\ cm^2$$

$$\underline{\therefore \textbf{ Select } \emptyset 12/20, \textbf{with As } = 5.655\ \textbf{cm}^2}$$

4) Bending Negative Moment

$$M_u = -64.3\ KN.m$$

$$Rn = \frac{Mn}{b \times d^2} = \frac{71.44 \times 10^6}{1000 \times 260^2} = 1.056\ MPa \qquad m = \frac{Fy}{0.85 \times F_{C'}} = \frac{420}{0.85 \times 24} = 20.6$$

$$Mn = \frac{Mu}{\emptyset} = \frac{64.3}{0.9} = 71.44\ KN.m$$

$$\rho_{req} = \frac{1}{m} \times \left(1 - \left(\sqrt{1 - \frac{2 \times Kn \times m}{Fy}}\right)\right) = \frac{1}{20.6} \times \left(1 - \left(\sqrt{1 - \frac{2 \times 1.056 \times 20.6}{420}}\right)\right) = 0.00258$$

$$As_{req} = \rho_{req} \times b \times d = 0.00258 \times 100 \times 26 = 6.72\ cm^2$$

- Check for $A_{s\ min}$.

$$As_{min} = 0.0012 \times b \times h = 0.0012 \times 100 \times 30 = 3.6\ cm^2$$

$$As_{req} = 6.72\ cm^2 > As_{min} = 3.6\ cm^2$$

5) Design of Horizontal Reinforcement.

$$As = As_{min}$$

$$According\ to\ ACI: \quad A_{smin}\ for\ two\ layers = 0.002 \times b \times h$$

$$For\ one\ layer;\ A_{smin} = 0.001 \times 100 \times 30 = 3\ cm^2/m$$

$$\underline{\therefore \textbf{ Select } \emptyset 10/25\ \textbf{cm}}$$

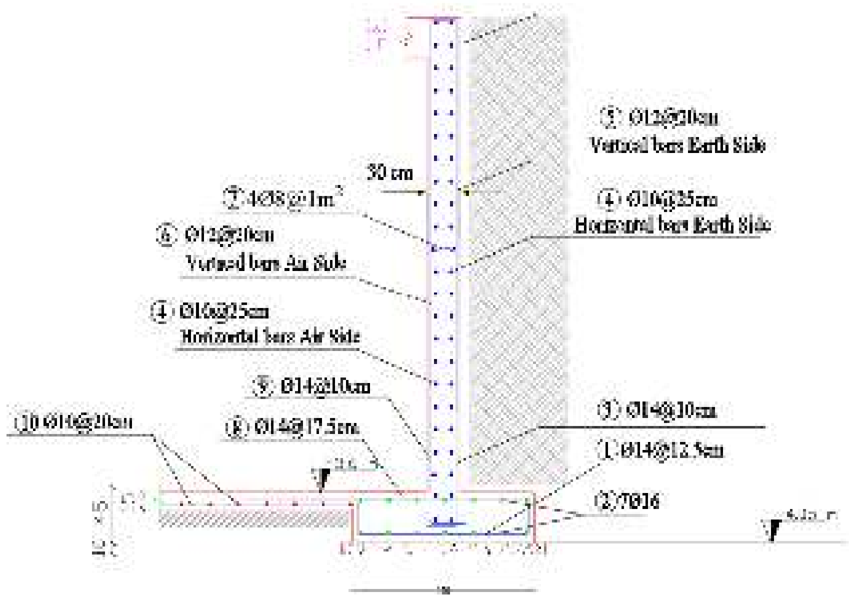

Fig. (4.22) reinforcment of basement wall

4.13 Design isolated rectangular Footing

In this section we will design isolated rectanfular footing , and we have the properties of siol from testing laborety, and we will design assume the dimension shown ing fig__ , we design according to (ACI-Code-318M-11) and we have the result :

Concrete B300 f_c'=24N/mm^2.

Reinforcement Steel f_y=420 N/mm^2.

Cover = 20mm.

γ_{soil}=18 KN/m^3 , $\emptyset_{soil}$=30.0^o

γ_{conc} = 25 kN/m^3 $\sigma_{b\text{-}allowable}$ =400 kN/m^2

P_D = 2000 kN & P_L = 750KN

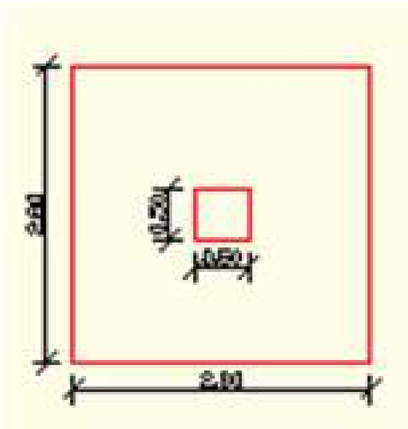

Fig. (4.23) Isolating footing

1) Design of Bearing Pressure.

Assume h = 80cm

For (1m^2) under the footing

Weight of soil = 18 x 1 = 18 kN/m^2

Weight of footing = 25 x 0.8 = 20 kN/m^2

Net allowable bearing pressure ($\sigma_{b\text{-}allowable}$)=400- 18 – 20-5 = 357 kN/m^2

Pu = 1.2 x PD + 1.6 x PL = 1.2 x2000 + 1.6 x 750 = 3600 kN

$$\frac{Pu}{A} \leq 1.4x\ \sigma_{b\text{-}allowable\text{ -net}}$$

$$\frac{3600}{2.8*2.8} = 459.18\ kN/m^2 < 1.4x357 = 499.8\ kN/m^2$$

<u>So, the Selected dimensions are O.K.</u>

2) Design of Reinforced Concrete.

a. Design of One Way Shear.

Depth of footing will be selected so that ($Ø \times V_c > V_u$) No shear reinforcement is required.

$$Ø \times V_c = 0.75 \times 1/6 \times \sqrt{(fc')} \times b \times d$$

$$d = h - cover - Ø = 800 - 75 - 16 = 709 \text{ mm}$$

$$V_u = 709 \times 0.816 \times 1.2 = 694.25 \text{ kN.}$$

$$Ø \times V_c = 0.75 \times \frac{1}{6} \times \sqrt{24} \times 2800 \times 709 = 1215.68 \text{ kN} > Vu\ 694.25 \text{ kN.}$$

h = 80 cm is O.K

b. Design of Two-Way Shear.

$$d = 709\text{mm.}$$

$$b_0 = 2 \times (500+709) + 2 \times (500+709) = 4836$$

$$B_c = 500/500 = 1 \quad , \quad \alpha_s = 40.$$

$$V_u = P_u - F_{RB} = 3600 - 459.18 \times 1.209 \times 1.209 = 2928.82\text{kN}$$

- $Ø \times V_c = 0.75 \times (1 + \frac{2}{1}) \times \frac{\sqrt{24}}{6} \times 4836 \times 709 = 6298.97$ kN.
- $Ø \times V_c = 0.75 \times (2 + \frac{40 \times 709}{4836}) \times \frac{\sqrt{24}}{12} \times 4836 \times 709 = 8256.21$ kN.
- $Ø \times V_c = 0.75 \times \frac{\sqrt{24}}{3} \times 4836 \times 709 = 4199.31$kN. (Controls)

So , $Ø \times V_c = 4199.3 \text{ kN} > Vu = 2928.82 \text{ kN}$

h = 80cm is O.K

c. Design of Bending Moment.

i. In X direction :

$$Mu = 459.18 \times 1.15 \times 2.8 \times 0.575 = 850.17\text{kN.m}$$

Design of rectangular section

$$R_n = \frac{M_u}{Øbd^2} = \frac{850.17 \times 10^6}{0.9 \times 2800 \times 709^2} = 0.67 Mpa. \qquad m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.6$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 0.67}{420}}\right) = 0.001622$$

➔ $A_{s,\,req} = \rho.b.d = 0.001622 \times 2800 \times 709 = 3219.99 \text{ mm}^2$.

Use18 Ø 16 Bottom with $A_{s,\,provided} = 3619.8 \text{ mm}^2 > A_{s,\,required} = 3219.99 \text{ mm}^2$. → Ok

ii. In Y direction :

$$Mu = 459.18 \times 1.15 \times 2.8 \times 0.575 = 850.17\text{kN.m}$$

Use18 Ø 16 Bottom with $A_{s,\ provided}$ = 3619.8 mm^2 > $A_{s,\ required}$ = 3219.99 mm^2. → Ok

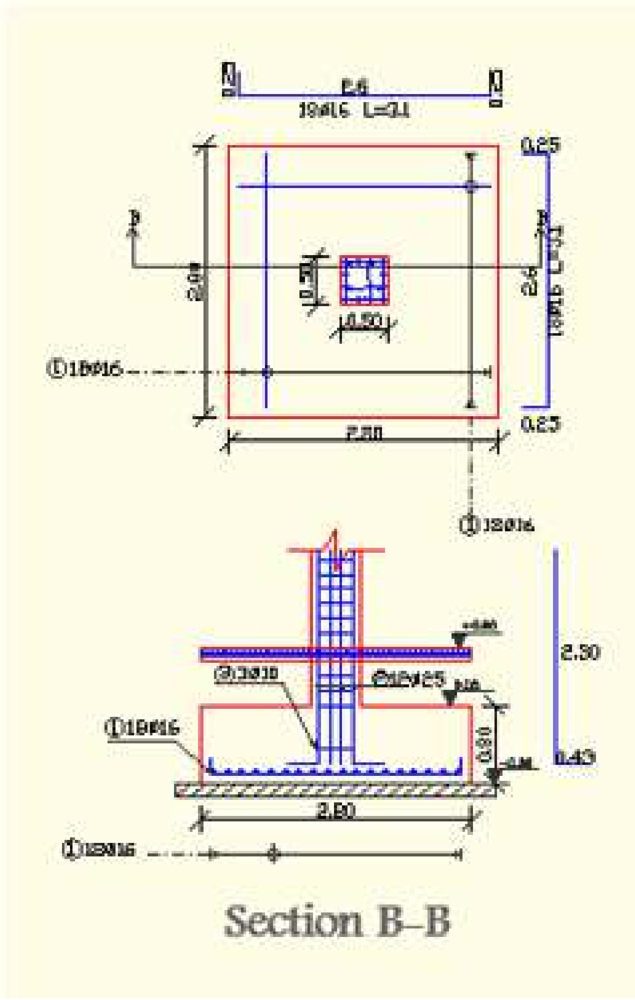

Fig. (4.24) reinforcement of isolating footing

CHAPTER 5
RESULTS AND RECOMMENDATIONS

5.1 Introduction

In this project, architectural plans were obtained that lacked many things. After studying all the requirements, they were completed preparing the comprehensive architectural and construction plans for the proposed hospital in the city of Halhul.
The structural plans were prepared in a detailed, accurate and clear manner to facilitate the construction process, and this report provides an explanation of all architectural and structural design steps for the building.

5.2 Results

1. Each student or structural designer must be able to design manually so that he can have experience and knowledge in the design programs and to emphasize the solution of the calculated programs and to understand how they work.

2. the factors that must be taken into consideration are the natural factors surrounding the building, the nature of the site, and the effect of natural forces on the site .

3. One of the most important structural design steps is how to link the various structural elements through the holistic view of the building and then segmenting these elements to design them individually and knowing how to design, taking into consideration the conditions surrounding the building .

5.3 Recommendations

This project increasing our understanding the construction projects with all their details, analyzes and designs. We would like here - through this experience - to present a set of recommendations, which we hope will be of benefit and advice to those planning to choose projects of a construction :

1. There must be coordination between the architectural and structural designer during the design process in order to result in an integrated building, both structurally and architecturally.

2. information about the site, its soil and the durability of the site's soil must be available through a geotechnical report specific to that area.

3. It is recommended to have a supervising engineer to supervise the implementation and to abide by the plans and conditions to ensure the best implementation of the project.

4.The electrical and mechanical design of the project must be completed before the start of implementation to edit any possible structural edit required .

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