Palestine Polytechnic University
College of Engineering
Civil Engineering Department

Civil Engineering
Graduation Project

Structural Design Of

" AL-Salam Ophthalmic Hospital "

In Hebron City

Project Team

Osama Abu E'ram **Ali Badawi**

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

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

" Al-Salam Ophthalmic Hospital " In Hebron City

submitted by Osama Abu E'ram and Ali Badawi for partial fulfillment of the requirements for the bachelor's degree.

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Structural Design for the

" Al-Salam Ophthalmic Hospital"

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ABSTRACT

Al-Salam Ophthalmic Hospital

The project aims to make a structural design for all the structural elements of a 5-storey hospital, with a total area of 4000 m2.

This is due to the importance of the structural design, as it is one of the most important stages that the building goes through, in which the locations of the columns and the structural systems for the various elements of the building are determined, and thus the initial architectural plans are converted into executable plans.

In order to achieve the goal of the project, the architectural plans were initially studied and the most appropriate mechanism was selected for distributing the structural elements in a way that does not contradict the architectural design of the building, Based on the Jordanian code for loads. After that we based on the American code ACI318-14 to design all of the structural elements by using a set of engineering programs. In the end, the executive plans were prepared for all the structural elements of the building structure to make the building feasible.

التصميم الإنشائي لـِ :

"مستشفى السلام التخصصي لطب العيون"

في مدينة الخليل

فريق العمل:

أسامة أبو عرام **علي بدوي**

إشراف:

د.ماهر عمرو

الملخص

يهدف المشروع الى عمل تصميم انشائي لجميع العناصر الانشائية المكونة لمستشفى مكون من 5 طوابق تقدر مساحتها الاجمالية بـ 4000 م^2. وذلك لما للتصميم الانشائي من أهمية فهو من أهم المراحل التي يمر بها المبنى والتي يتم فيها تحديد أماكن الاعمدة و الأنظمة الانشائية لمختلف عناصر المبنى، وبذلك يتم تحويل المخططات المعمارية الأولية إلى مخططات قابلة للتنفيذ .

وتحقيقا لهدف المشروع تم في البداية دراسة المخططات المعمارية و اختيار أنسب آلية لتوزيع العناصر الانشائية بما لا يتعارض مع التصميم المعماري للمبنى، ثم تم عمل دراسة انشائية مفصلة تم فيها تقدير الاحمال المتوقعة على جميع العناصر الانشائية بالاعتماد على الكود الاردني، بعد ذلك تم تحليل وتصميم جميع تلك العناصر بالاعتماد على الكود الأمريكي ACI318-14 وباستخدام مجموعة من البرامج الهندسية . وفي النهاية تم إعداد المخططات التنفيذية لجميع العناصر الانشائية المكونة لهيكل المبنى ليصبح المبنى قابلاً للتنفيذ .

DEDICATION

To those who have always believed in us …

To those who have been our source of inspiration …

To those who gave us strength …

To those who provide us their endless support and encouragement …

To our families …

Project Team

ACKNOWLEDGEMENT

It has been a great opportunity for us to gain a lot of knowledge through working on this project ,but the successful completion of any task would be incomplete without mention of the people who made it possible.

For that we would like to thank everyone who helped, supported and encouraged us :

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

Special thanks to our supervisor **Dr. Maher Amro**, who was the guiding light every step of the way as we worked for this project .

Thanks for all instructors for all efforts they did to provide us with all useful information and sharing their knowledge and experience to make from us successful engineers .

Finally, our deep gratitude and sincere thanks to our parents, brothers and sisters for their patience, for everyone who tried to help us during our work and gave us strength to complete this task.

Project Team

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LIST OF ABBREVIATIONS

As Area Of Non-Prestressed Tension Reinforcement.

As′ Area Of Non-Prestressed Compression Reinforcement.

Ag Gross Area Of Section.

Av Area Of Shear Reinforcement 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.

d Distance From Extreme Compression Fiber To Centroid Of Tension Reinforcement.

Ec Modulus Of Elasticity Of Concrete.

fy Specified Yield Strength Of Non-Prestressed Reinforcement.

h Overall Thickness Of Member.

I Moment Of Inertia Of Section Resisting Externally Applied Factored Loads.

ln Length Of Clear Span , Measured Face-To-Face Of Supports In Slabs Without Beams And Face To Face Of Beam Or Other Supports In Other Cases.

M	Bending Moment.
Mu	Factored Moment At Section.
Mn	Nominal Moment.
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.
ρ	Ratio Of Steel Area.
εc	Compression Strain Of Concrete=0.003mm /Mm
Fsd,r	Total Additional Tension Force Above The Support.
Ved,0	Shear Force At Critical Section.
Vu	Factored Shear Force At Section.
Wu	Factored Load Per Unit Length.
Φ	Strength Reduction Factor.

CHAPTER 1 : INTRODUCTION

Figure 1- 1 3D photo for the hospital

1.1 Introduction

Civil engineering affects many of our daily activities: the buildings we live in and work in, the transportation facilities we use, the water we drink, and the drainage and sewage systems that are necessary to our health and well-being.

Civil engineers:

1. Measure and draw a map of the earth's surface.
2. Design and supervise the construction of bridges, tunnels, large buildings, dams, and coastal structures.
3. Plan, layout, construct, and maintain railroads, highways, and airports.
4. Devise systems for the control and efficient flow of traffic.
5. Plan and build river navigation and flood control projects.
6. Provide plants and systems for water supply and sewage and refuse disposal.

To build may be a primal urge. Our constructions, while they may be simply for shelter or transportation, often include aesthetic touches that are there to make us feel good about what we have built. Thus, bridges have geometrical designs intended to support weight, but they also have an artistic detailing and a "look" that defines the era in which they were built. In constructing buildings, highways, and bridges, civil engineers work with architects to develop the appearance of the structure. Ugly buildings represent a failed communication between the two professionals; a building that falls down, or cannot be maintained, also represents a failure, but one that the civil engineer could possibly have prevented. Civil engineering is much more than erecting skyscrapers or bridges.

1.2 General Overview

We chose one of the hospitals in Hebron , a hospital that specializes in Ophthalmology, to provide an introduction to the graduation project and to conduct an integrated structural study that includes structural analysis and design of building elements so that they can withstand loads that affect the building.

One of the important things a person always searches for is the appropriate design that provides comfort in use, so choose the right place to build the building and search for engineers with the skills and experience to design and implement the building in terms of "Architectural, Civil Engineering, Electrical and Mechanical engineering " so that users find the feeling of being comfortable in the place.

1.3 Project Problem

The problem of this project in the work of the structural design of the building that was chosen to be the field of this research, where the study was done in the work of a study of the work of equilibrium of the entire building on implementation to avoid any risk to users of this building, and in this project will be analyzed each of the elements of construction such as : beams, columns, foundations, and other structural elements, and determine the loads located on the structural elements of the loads of live or dead loads resulting from the node and the entire elements built in the structure.

As well as taking into account the safety factor of the building and that the economic aspect and enable the achievement of the highest resistance to safety, and then the work plans of the structural elements that have been designed, to move this project from the proposal to the implementation.

why this project was chosen?

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

for being a specialty hospital, and other reasons can be summarized as follows:

1.1 The project is a specialized hospital that enables us to study and analyze the structural elements in line with the scientific qualifications and skills that we gained through studying in the field of engineering professions.

1.2 Because this project is widely implemented in our society and the need to implement buildings in an engineering manner.

1.3 The need to increase the experience and skill of structural design, which we studied and applied in practice by linking the relationship between the theoretical aspects that have been gained from the courses studied in this specialization, and the application of this in this project and its structural elements, and design of structural elements to suit the loads On the structural elements, taking into account the provision of durability, strength, durability and economy.

1.4 Project Objectives

This Project was chosen to achieve the following goals:

- Correlate the theory that has been gained in the design courses with practical life.
- Increase the ability to choose a suitable structural system of elements that meets design requirements.
- Get experience in dealing with different problems encountered in the design process.
- Practice the structural analysis and design programs as well as theoretical knowledge.

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.
6. Project Writing in which all these stages were presented in detail.

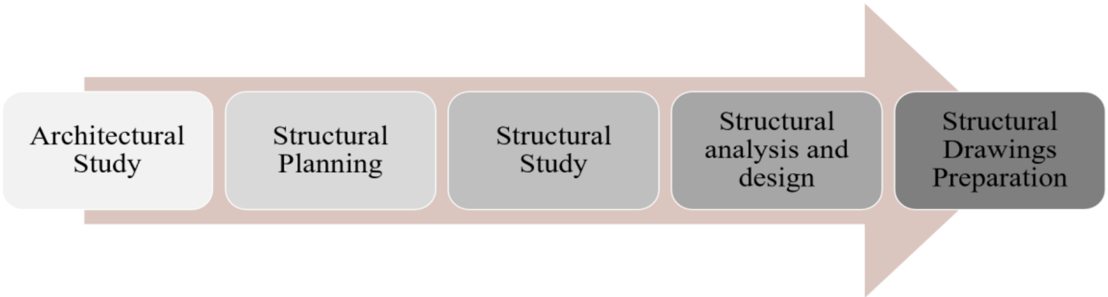


Figure 1- 2 Work Procedure

1.6 Project Scope

This Project contains the following Chapters :

CHAPTER 1: A general introduction.

CHAPTER 2: An architectural description of the project.

CHAPTER 3: A general description of the structural elements.

CHAPTER 4: Structural analysis and design of all structural elements.

CHAPTER 5: Results and Recommendations.

1.7 Project Timeline:

The following chart shows the project plan and timeline :

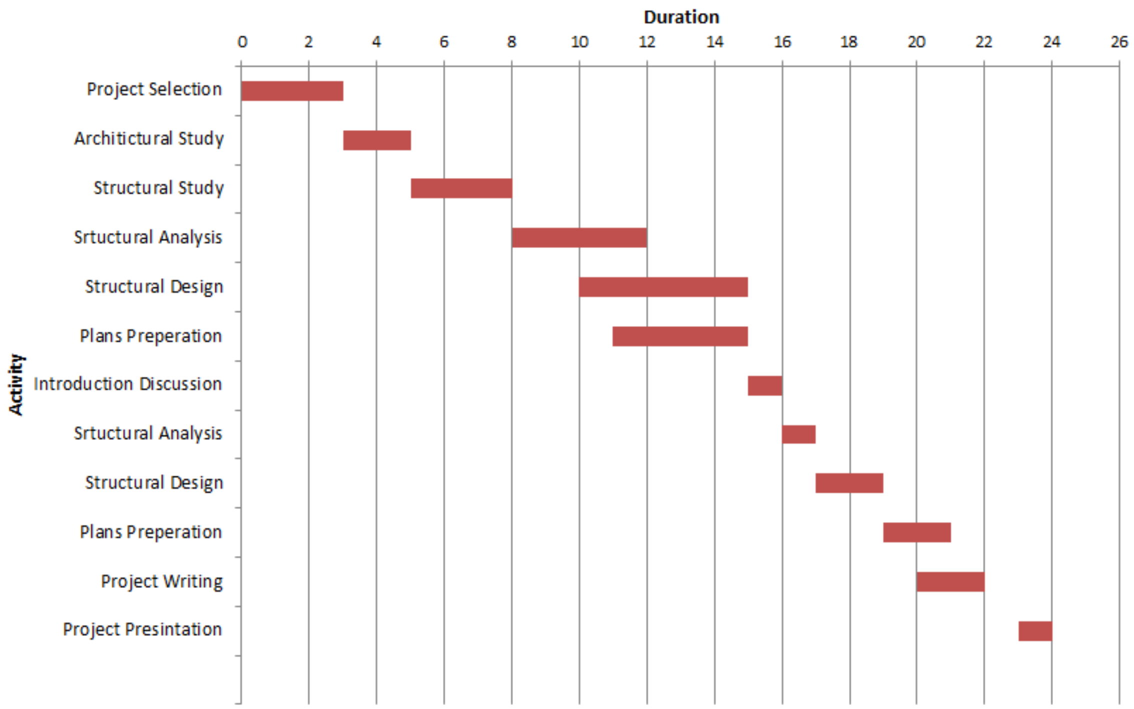


Figure 1- 3 Project Time line

1.8 Programs used in the project

There are several computer programs used in this project:

1. AUTOCAD 2019: for detailed drawings of structural elements.
2. ATIR18: Structural design and analysis of structural elements.
3. Safe16: design of Two way ribbed slabs .
4. Microsoft Office word : for writing the text project.

CHAPTER 2 : ARCHITECTURAL DESCRIPTION

Figure 2- 1 3D photo for the hospital

2.1 Introduction

Building any structure is an integrative process between several engineering specializations and the design process for any building takes place through several stages until it is fully accomplished.

Starting first with the architectural design stage, at this stage, the shape of the structure is determined and take into account the inquiry of the various functions and requirements for which you will create this building, here the initial distribution of the facilities is made, to achieve the required spaces and dimensions, and in this process, lighting, ventilation, movement, mobility, and other functional requirements are also studied.

An 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 view of the project and therefore it will be possible to locate the columns and other structural elements to suit architectural design.

2.2 General Identification of the project

This hospital is located in the Hebron area on a plot of 2500 m 2 , with an area of approximately 4,000 square meters. It consists of 5 floors ; 4 floors over the ground and one underground floor. The hospital has a main entrance and an emergency entrance on the western side .

The underground floor that are used as a car park and complement the health and medical services complement the health and medical services. The area this floor is 1602 m^2.

Figure 2- 2 3D photo for the hospital

The ground floor consists of an emergencies rooms, clinics, a pharmacy, cafetearea and W.C . The total area of this floor is 841 square meters.

The first floor consists of patient preparation room, operations rooms, Lasik rooms, nurses rooms and clinics, with an area of 810 square meters.

And the second floor consists of men's bedrooms, women's bedroom, meeting room, general manager office and cafeteria, and its area is 615 square meters.

And the third floor (roof floor) consist of lecture hall and video conference hall, with an area of 166 square meters .

2.3 General site description

The hospital will be established in Hebron – Al-Salam Street near Al-Ansar of gas station, where this is land has an area of 2505 m^2. The total area of the hospital is 4,034 m^2.

The hospital is located in an excellent location in this area and is accessible by public transport and several streets connected to it.

Figure 2- 3 Project Location

2.4 Floors Description

The project has three types of floors: one basement floor, ground floor, and 3 residential floors with a total area of 4034 m^2. The following is a brief description of each floor.

1. BASEMENT FLOOR :

The basement floor level is 3.05 m below the level of Main Street with an area of 1602 m^2. It is used as a parking lot and contains an entrance and exit for cars, services rooms for the hospital like: Boiler room and generator room, medicine warehouse, kitchen and an elevators and stairs for transport into the building.

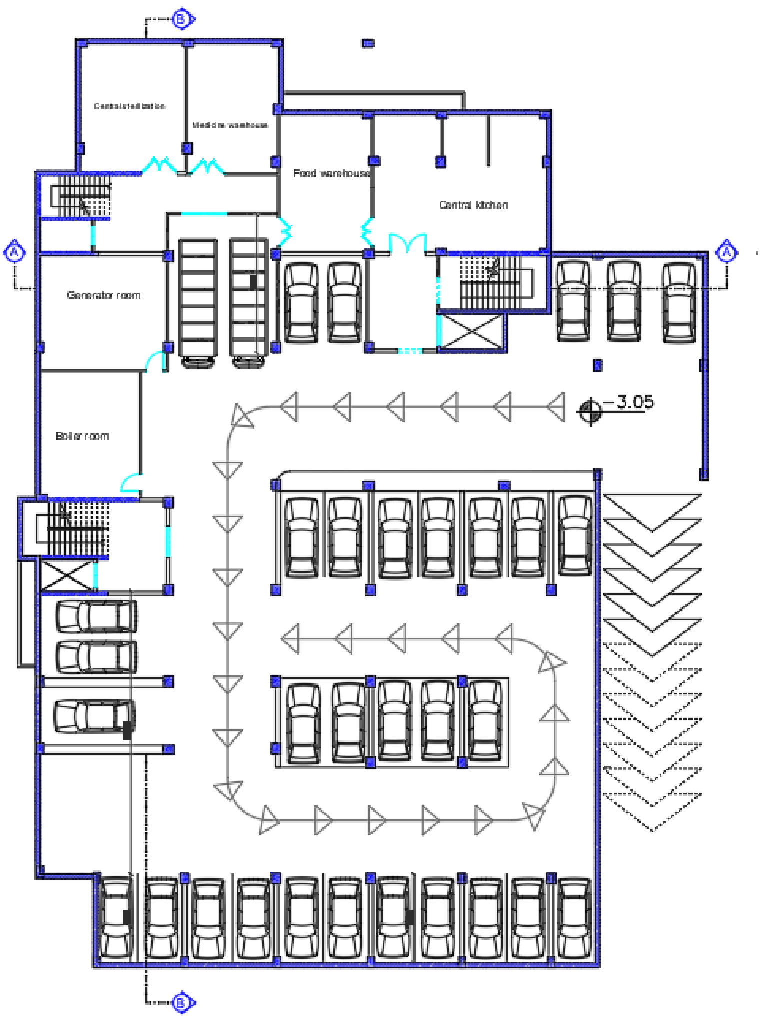


Figure 2- 4 Basement Floor

2. GROUND BASEMENT FLOOR:

The ground floor consists of two emergency rooms, several clinics, a waiting room and a cafeteria, with an area of 841 m^2.

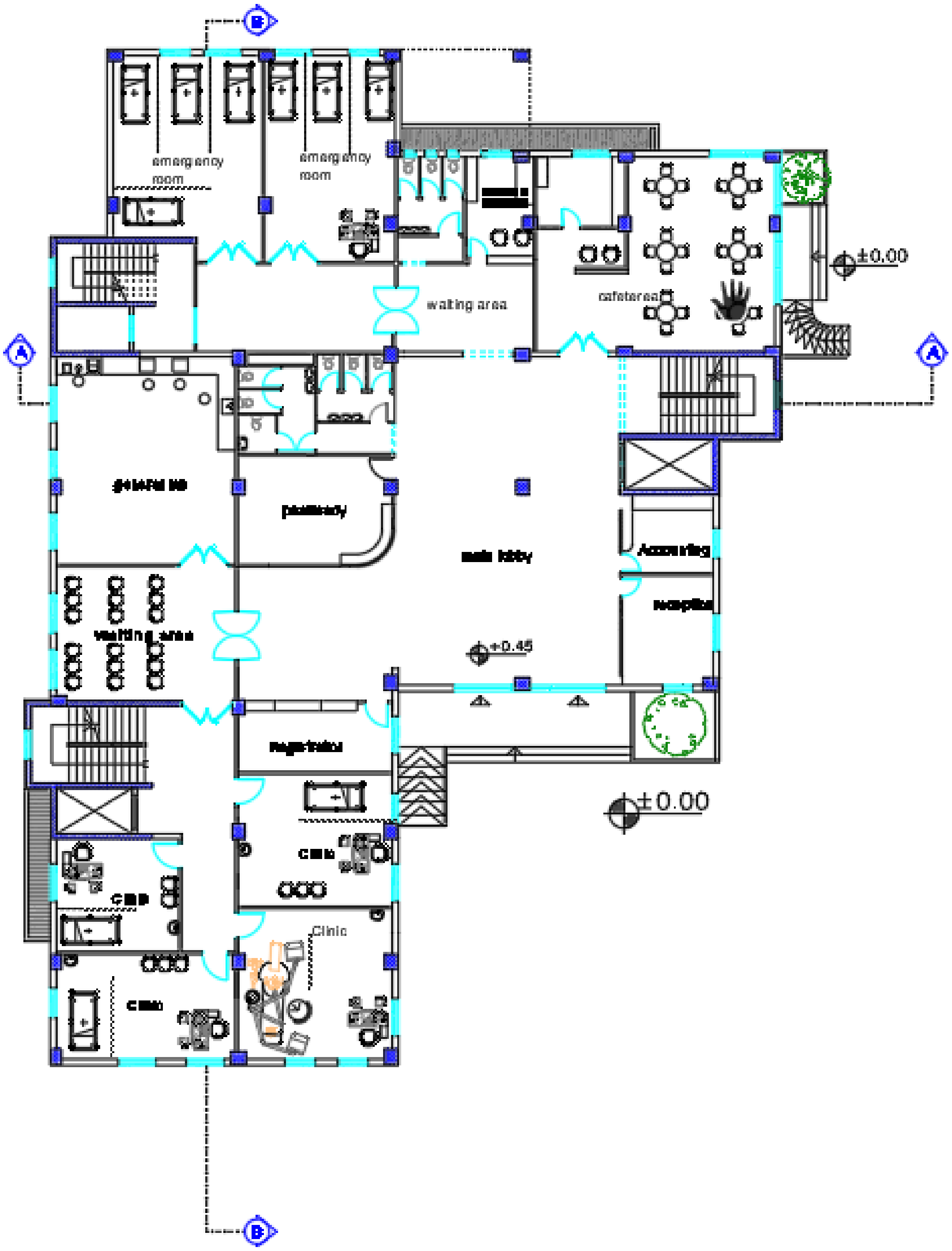


Figure 2- 5 Ground floor

3. FIRST FLOOR

The first floor contains a waiting room, a restroom, several clinics, and staff rooms, with an area of 810 m^2.

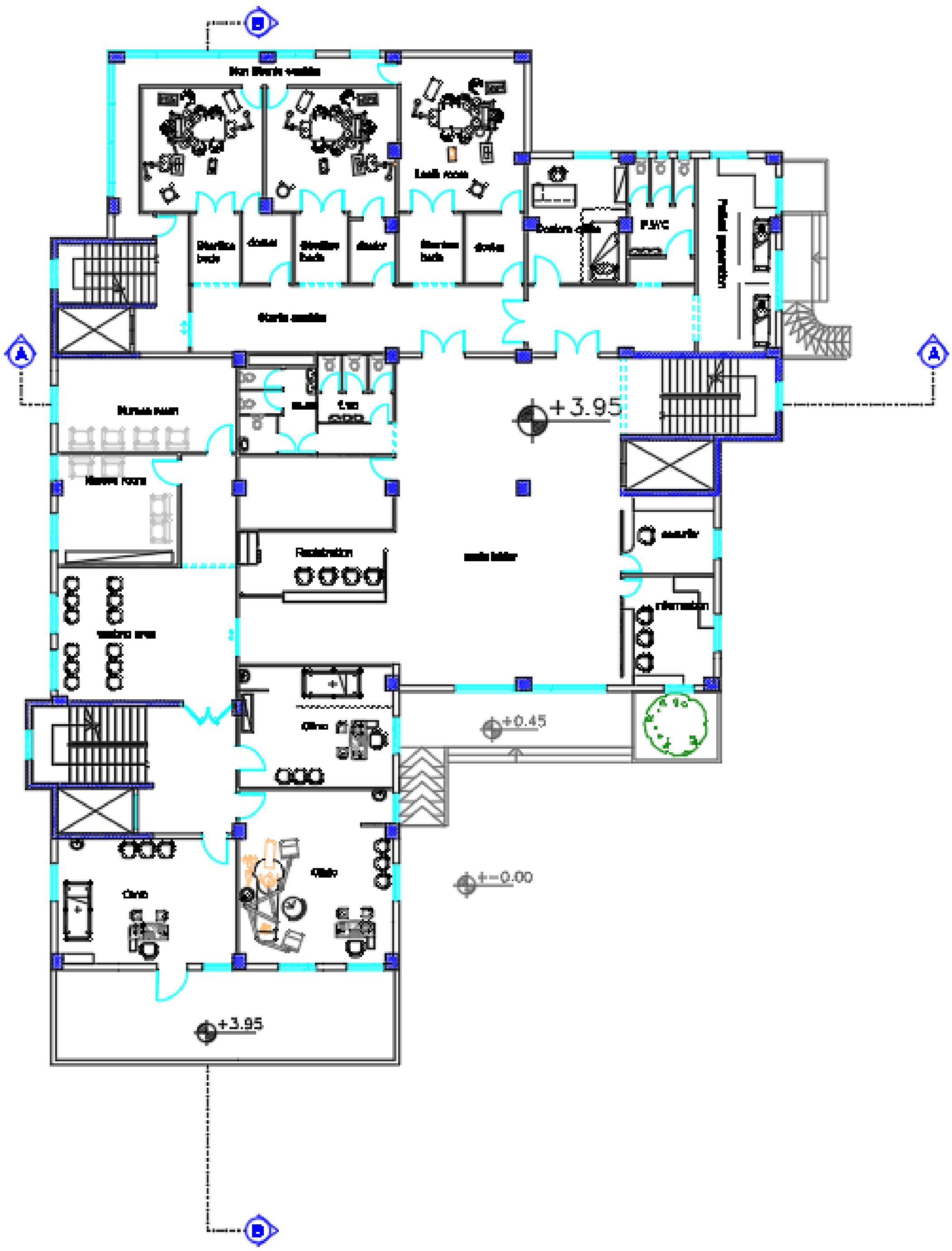


Figure 2- 6 First floor

4. Second FLOOR:

The second floor consists s bedrooms, meeting rooms and cafeteria with an area of 615 m^2.

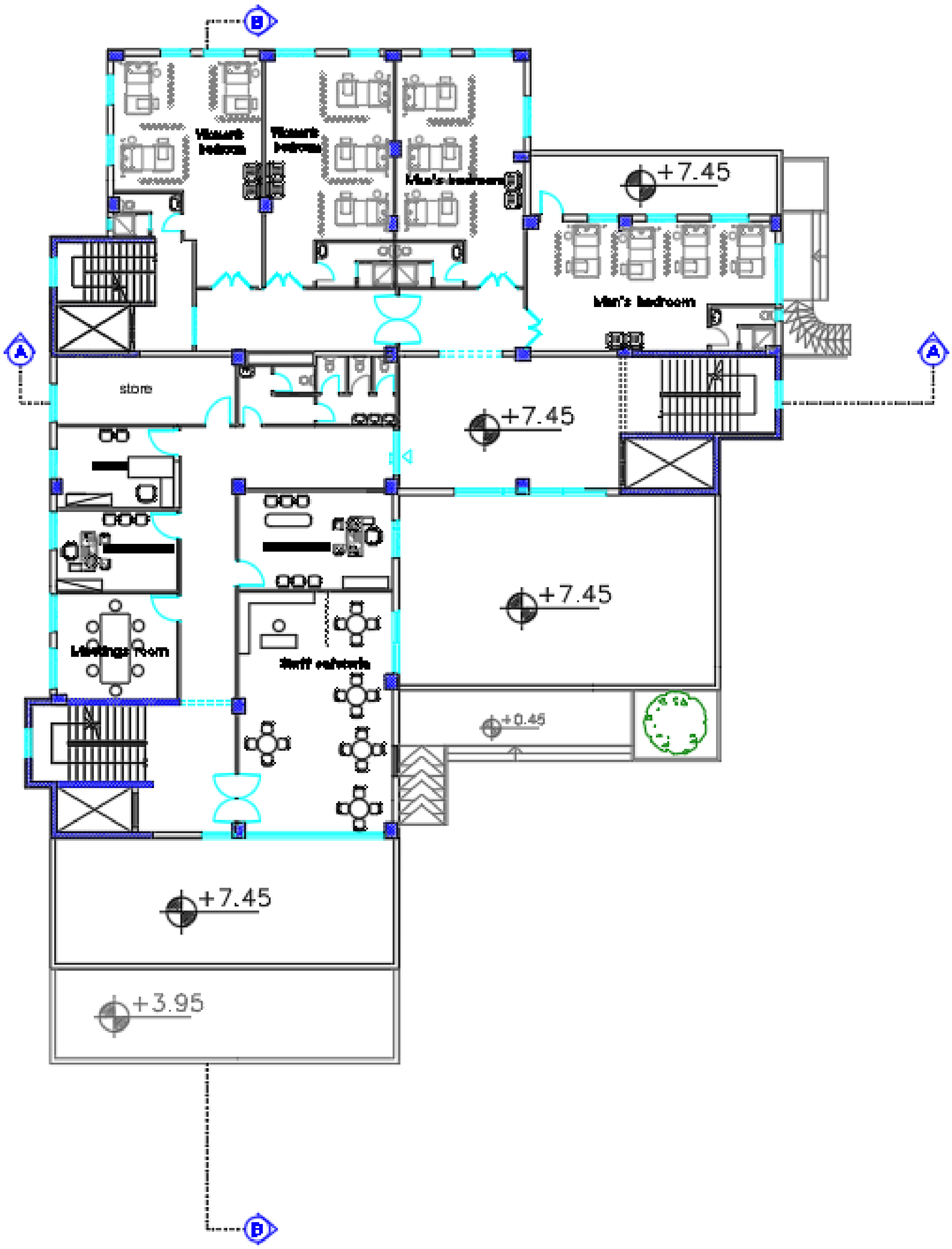


Figure 2- 7 Second floor

5. THIRD FLOOR:

The third floor (roof floor) consists meeting room and a lecture hall, and its area is 166 m^2.

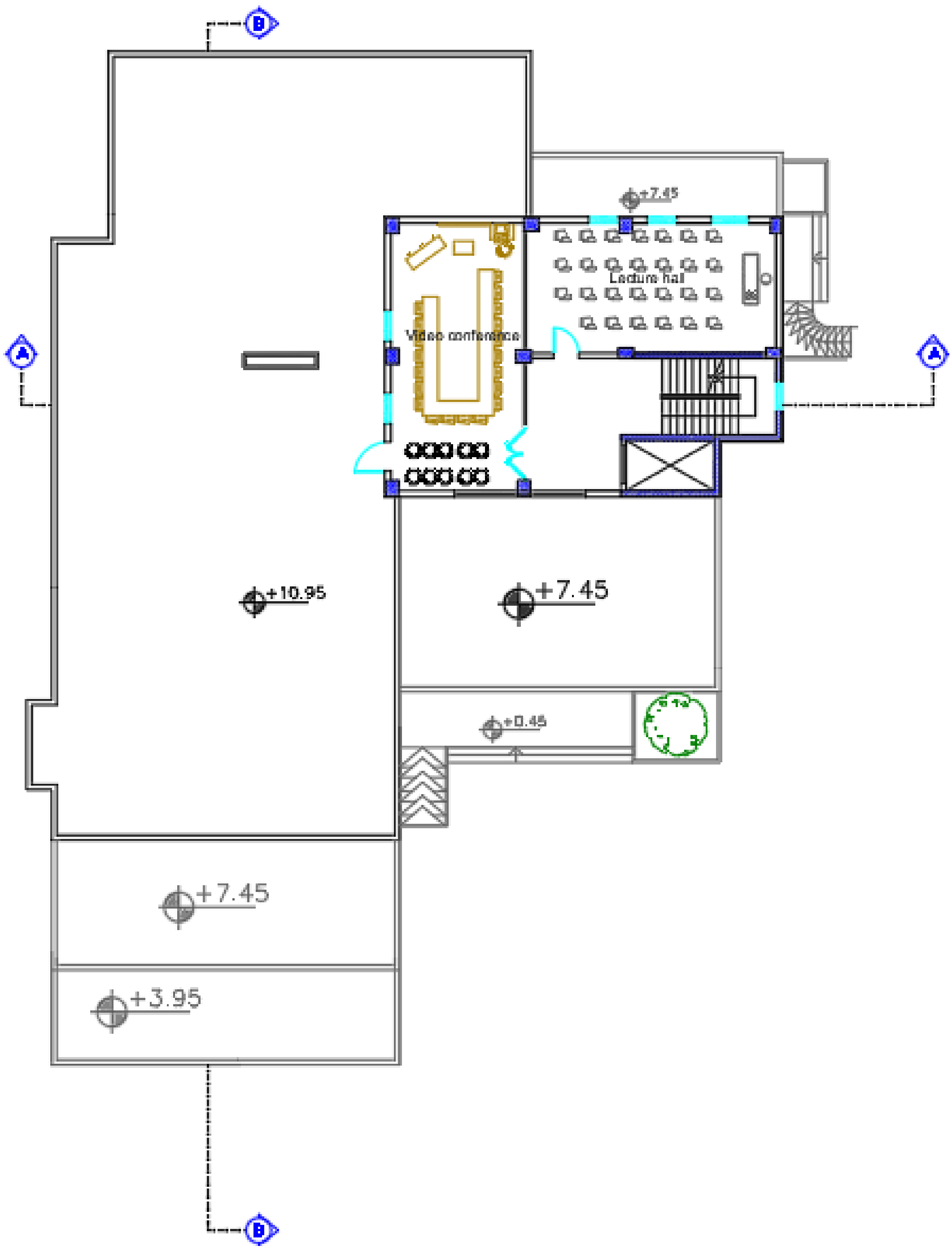


Figure 2- 8 Third floor

2.5 Elevations Description

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

2.5.1 West elevation :

The western elevation shows the main entrance to the hospital, and it also shows a repeating staircase facade, in addition to some architectural protrusions.

Figure 2- 9 West Elevation

2.5.2 East elevation:

The eastern elevation shows a staircase. The staircase shows the architectural protrusion on the second floor clearly with symmetry in the openings and protrusions.

Figure 2- 10 East Elevation

2.5.3 North elevation:

The northern elevation shows the beauty of the architectural gradation appears on the floors

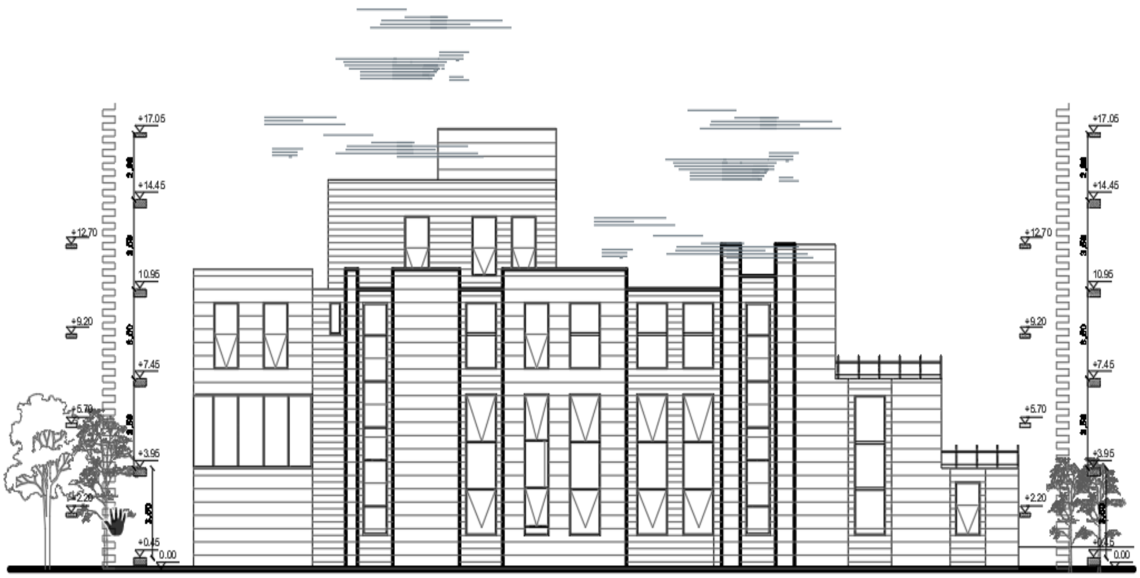


Figure 2- 11 North Elevation

2.5.4 South elevation:

The southern elevation shows the entrance to the emergency department appears with some architectural protrusions and symmetry in the openings to give a harmonious and integrated appearance of the building.

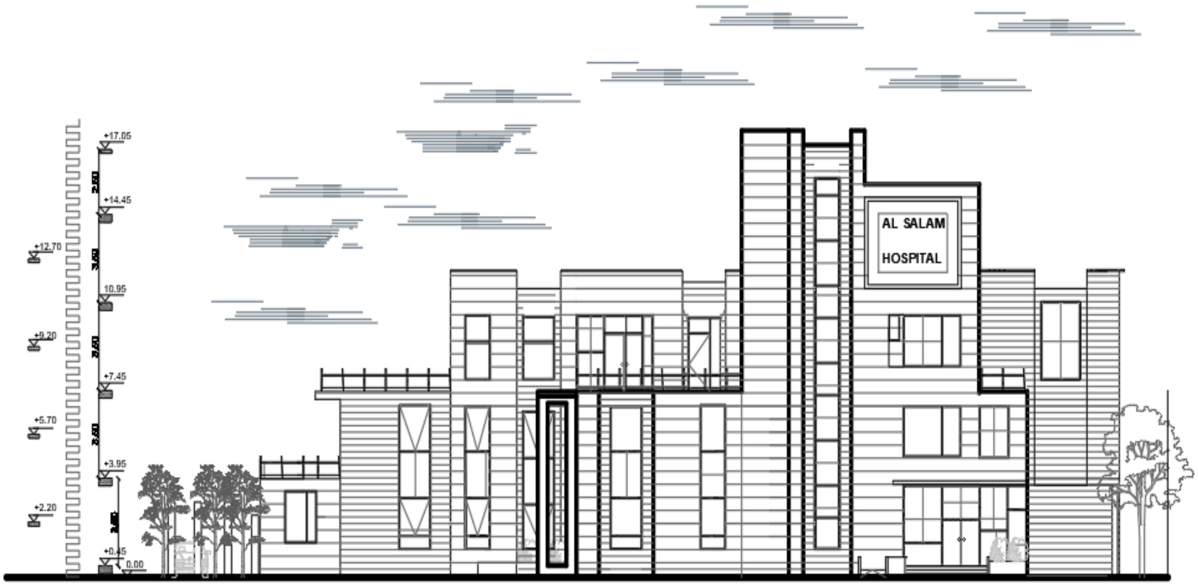


Figure 2- 12 South Elevation

2.6 Sections of the building

These sections explain the movement inside the building through the stairs and elevator. It also shows more details for the heights and levels for slabs, windows, and doors.

Figures (2-12) and (2-13) shows two sections of the building.

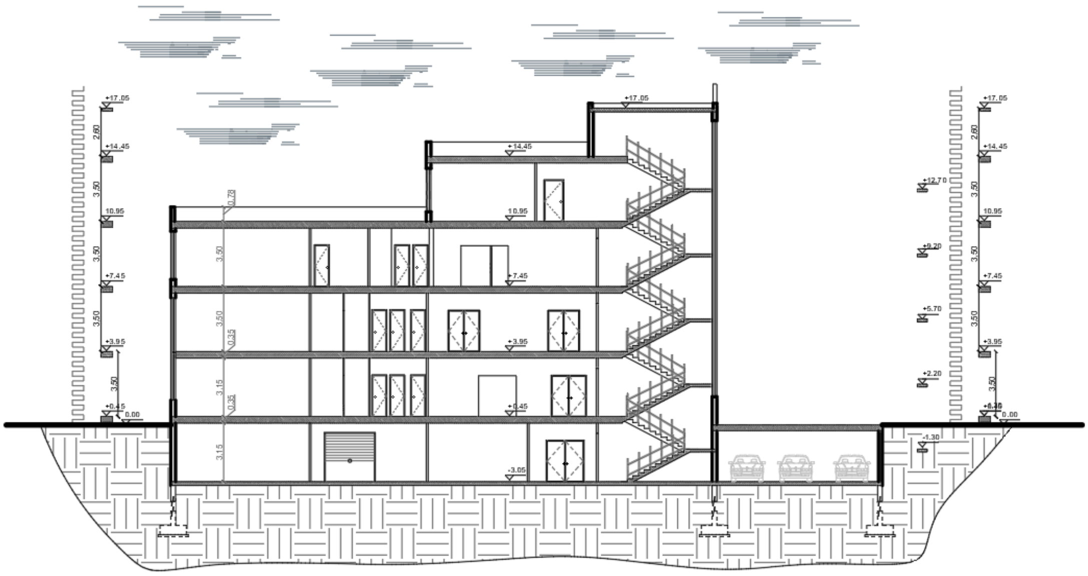


Figure 2- 13 Section A-A

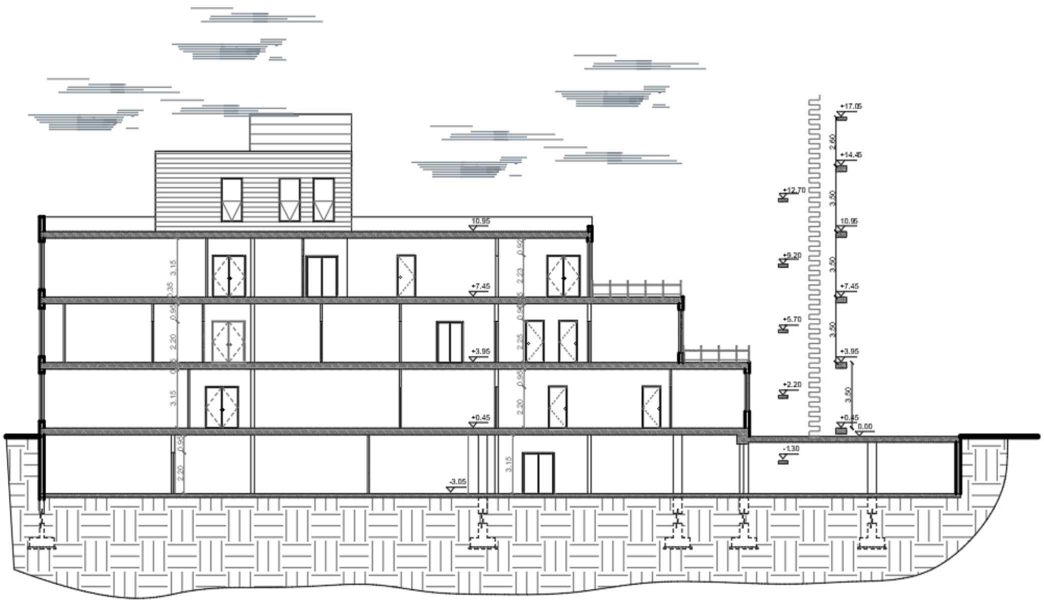


Figure 2- 14 Section B-B

CHAPTER 3 : STRUCTURAL DESCRIPTION

3.1 Introduction
3.2 The Aim of the Structural Design
3.3 Scientific Tests
3.4 Loads Acting on the Building
3.5 Structural Elements of the Building (beams and slabs)

Figure 3- 1 3D photo for the hospital

3.1 Introduction

After completion of the architectural study of the building, A study of the structural elements was done to determine the optimal structural system for the building to make the best design of all structural elements.

After the human known the structural design, it was necessary to evolve its structural design to provide two basic factors, namely safety and economy.

Therefore, it is necessary to identify the structural structures that make up the project in order to choose the best and optimal elements so as to achieve safety and economy, in addition to not to conflict with the architectural plans laid down, and the purpose of the process of structural design is to ensure that the necessary operating advantages, while preserving as much as possible On the economic factor.

So In this chapter, the structural elements of the project will be identified and explained.

3.2 The Aim of the Structural Design

The main purpose of structural design is to make a safe, economic, and serviceable design, so In designing a structure the following objectives must be taken into consideration :

1- **Safety**: The structure should be able to carry all expected loads safely, without failure, that is, without breaking or collapsing under the loads.

2- **Durability:** The structure should last for a reasonable period of time.

3- **Stability:** to prevent overturning, sliding, or buckling of the structure, or parts of it, under the action of loads.

4- **Strength:** to resist safely the stresses induced by the loads in the various structural members.

5- **Serviceability**: To ensure satisfactory performance under service load conditions which implies providing adequate stiffness and reinforcements to contain deflections, crack-widths, and vibrations within acceptable limits, and also providing impermeability and durability (including corrosion-resistance), etc.

There are two other considerations that a sensible designer must bear in mind, economy and aesthetics. As any engineer can always design a massive structure, which has more than adequate stability, strength, and serviceability, but the ensuing cost of the structure may be exorbitant, and the end product, far from aesthetic.

3.3 Scientific Tests

Before the structural study of any building, there is the work of geotechnical studies of the site, which means all work related to exploring the site and studying soil, rocks, and groundwater, then analyzing information and translating it to predict the way the soil behaves when building on it, and the most important thing is to obtaining soil durability (Bearing Capacity) required to design the building's foundations.

3.4 Loads Acting on the Building

Loads that acting on the building 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, and loads of earthquakes.

3.4.1 dead loads

Dead loads consist of the weight of all materials of construction incorporated into the building including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding and other similarly incorporated architectural and structural items.

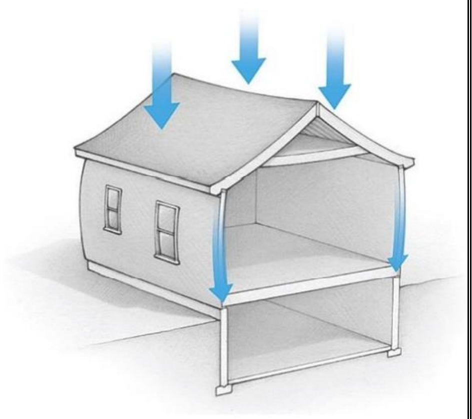


Figure 3- 2 Dead Load

3.4.2 live load

Live loads are those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load, or dead load. We take LL = 5 KN/m^2

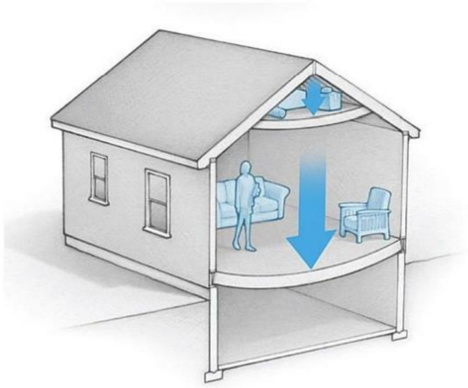


Figure 3- 3 Live load

3.5 Structural Elements of the Building

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

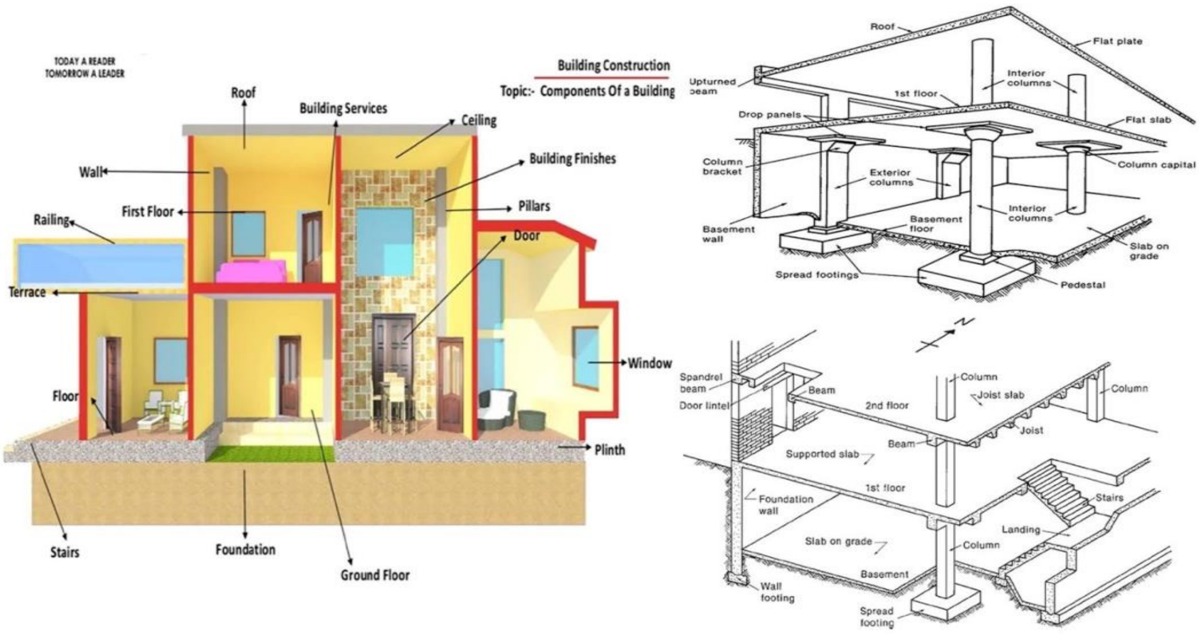


Figure 3- 4 Structural elemetns of R.C structure

3.5.1 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, without distortions.

There are many different Structural systems of reinforced concrete slabs, including the following:

3.5.1.1 Solid slab (one or two way)

Solid Slabs are fully customizable concrete slabs of varying width, length, and thickness. They can be used in a variety of applications such as bridges, piers, and building floors. It is known that solid slabs should be supported by drop beams.

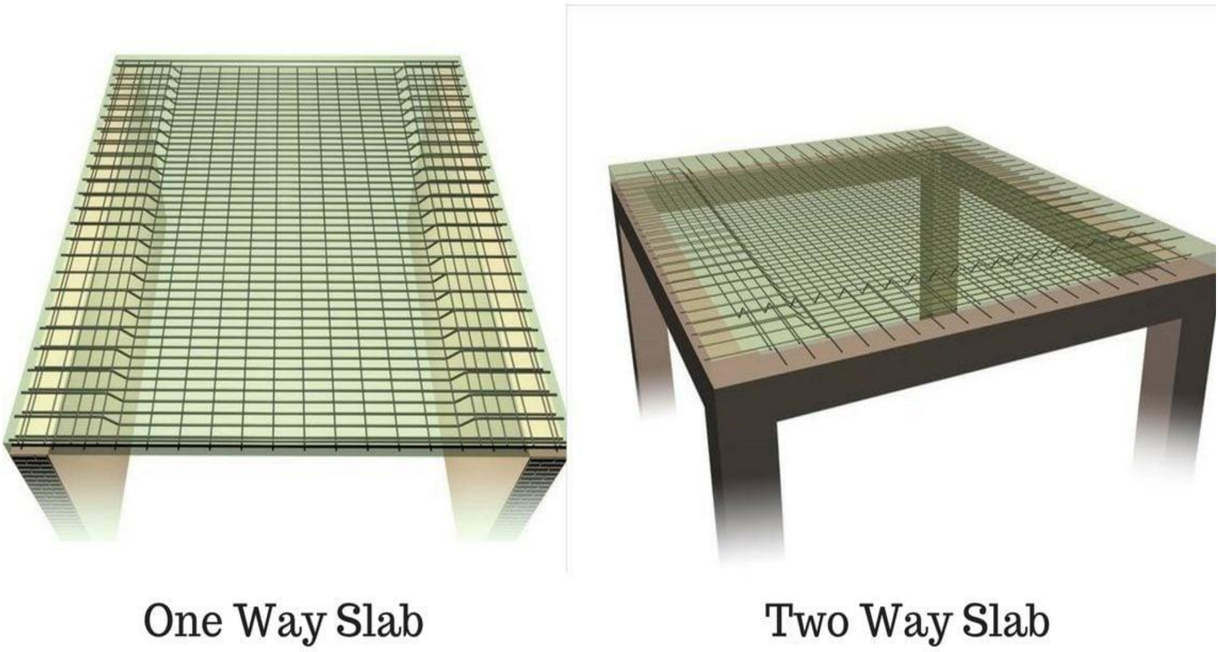


Figure 3- 5 Solid slab

3.5.1.2 Ribbed slab (one or two way)

It’s the most common system used in Palestine. They are made up of wide band beams running between columns with narrow ribs spanning the orthogonal direction. Normally the ribs and the beams are the same depth. A thin topping slab completes the system. It can be designed to carry loads either in one direction only, or in two directions.

Figures (3-8),(3-9) describe one-way and two-way ribbed slabs respectively.

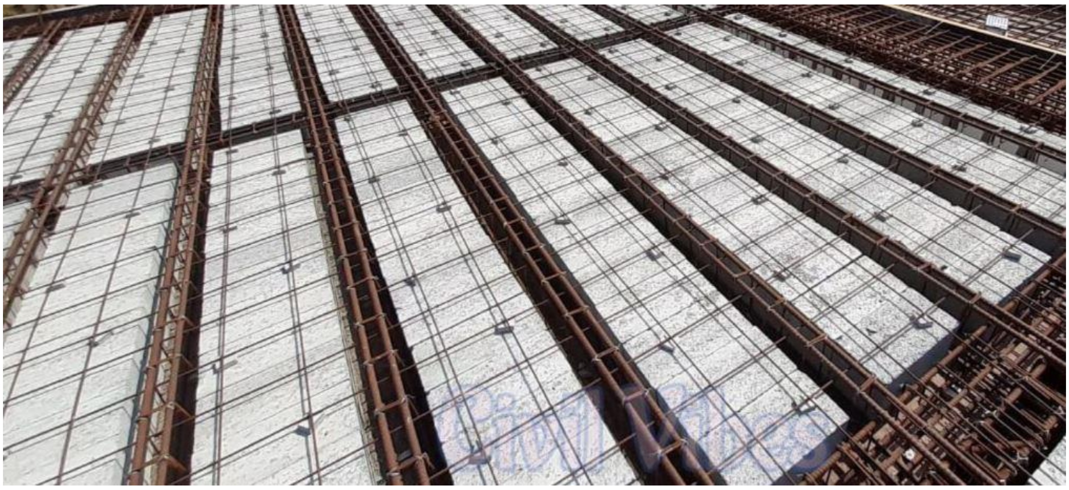


Figure 3- 6 One way rib slab

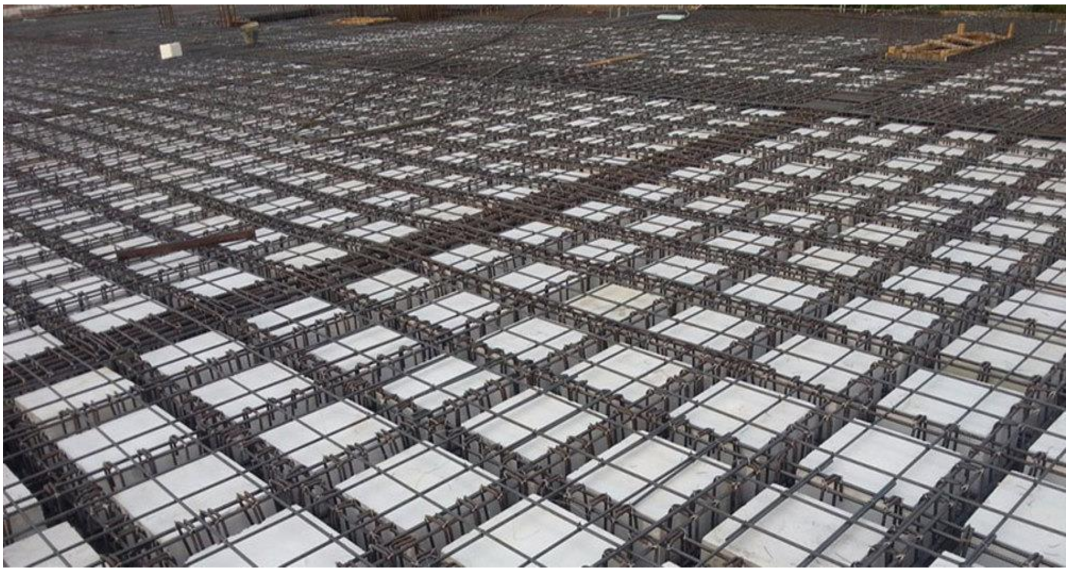


Figure 3- 7 Two way rib slab

3.5.2 Beams

They are basic structural elements in transferring loads from slabs to the columns, and they are of two types, hidden inside the slab and Dropped Beams that emerge from the slab from the bottom.

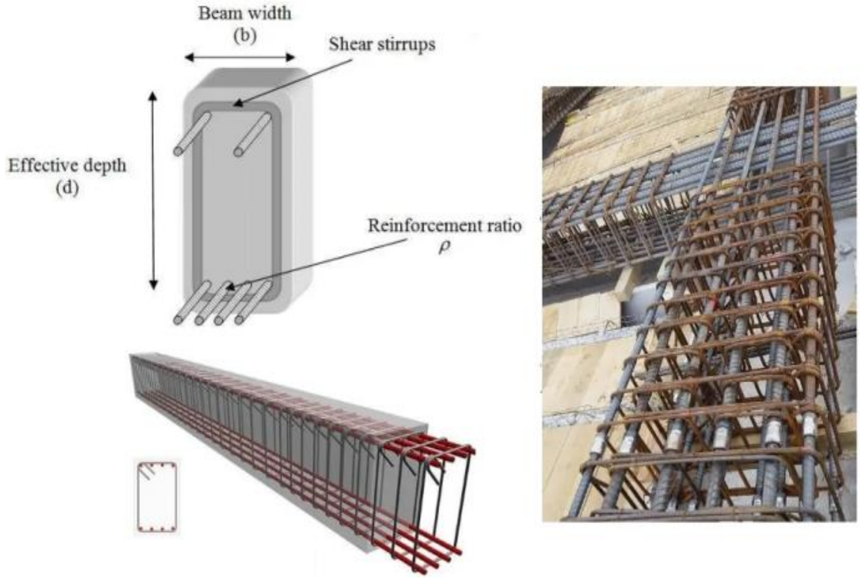


Figure 3- 8 Beams

3.5.3 Columns

Column is a vertical structural member that carry loads mainly in compression.

It might transfer loads from a ceiling, floor slab, roof slab, or from a beam, to the foundations. Commonly, columns also carry bending moments about one or both of the cross-section axes.

Figure 3- 9 Columns

3.5.4 Shear Walls

Shear wall is a vertical structural element used to resist vertical and horizontal forces such as wind force and seismic force.

The reinforcement is provided in both horizontal and vertical directions. But at the end of each wall, bars are closely spaced and anchored. So, the end zones of RC shear wall is called as boundary elements or barbells. The wall thickness of RC shear wall is varied depending upon many factors like thermal insulation requirements of building, age of building, number of floors of building.

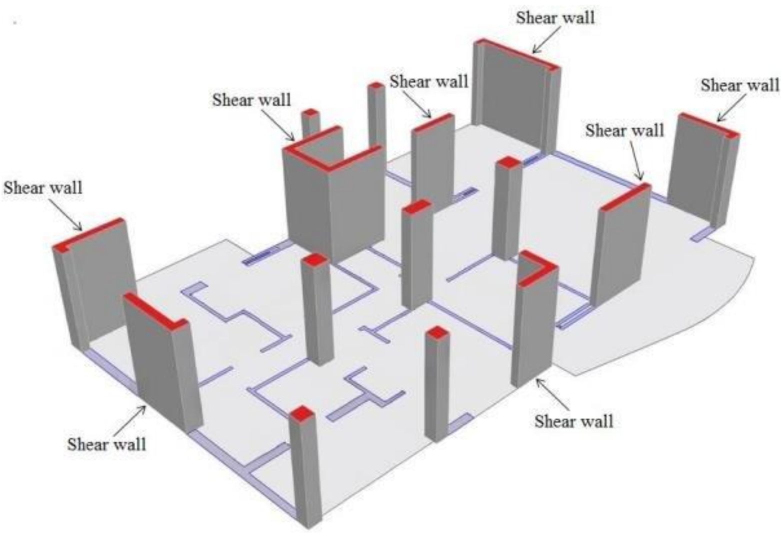


Figure 3- 10 Shear Walls

3.5.5 Foundations.

foundation is the lowest part of the building or the civil structure that is in direct contact with the soil which transfers loads from the structure to the soil safely.

Loads act on foundations came from the loads on the slabs which transferred to the beams, to the columns then to the foundations. And the foundations transfer the loads to the soil.

There a many types of foundations that can be used in each project it depends on the type of loads and the nature of the soi in the site.

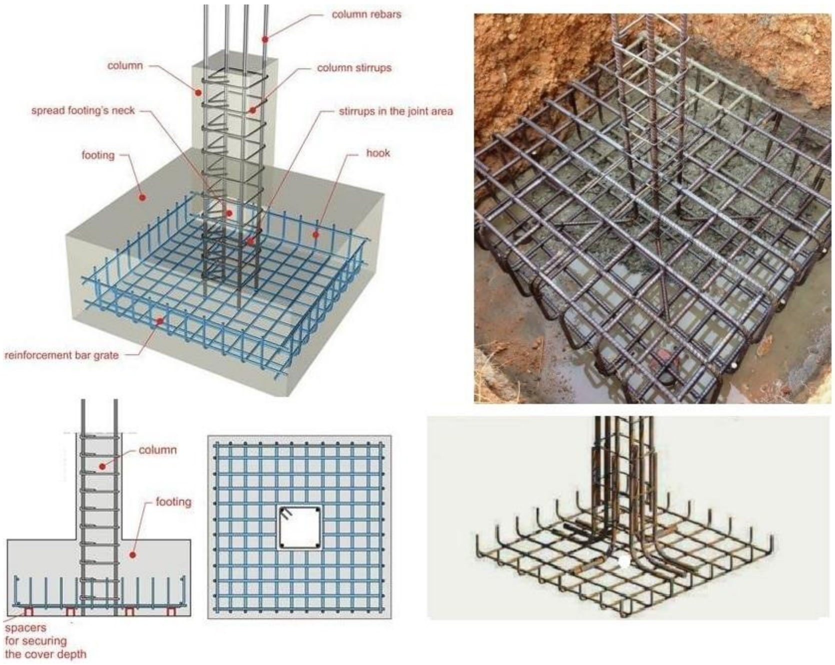


Figure 3- 11 Foundation

3.5.6 Stair

A staircase is an important component of a building that is planned and designed based on the type and orientation of the building. Therefore, it is impossible to recommend a definite dimension for the stair without a clear idea about, it is consist of rise and landing.

Figure 3- 12 Stair

CHAPTER 4 : STRUCTURAL ANALYSIS AND DESIGN

4.1 Introduction
4.2 Factored load
4.3 Determination of slab thickness
4.4 Design of topping
4.5 Design of one-way ribbed slab
4.6 Design of Beam B43
4.7 Design of Two-way ribbed slab
4.8 Design of column (C)
4.9 Design of shear wall
4.10 Design of isolated footing (F1)
4.11 Design of stair.

Figure 4- 1 3D photo for the hospital

4.1 Introduction

Concrete is the only major building material that can be delivered to the job site in a plastic state. This unique quality makes concrete desirable as a building material because it can be molded to virtually any form or shape.

Concrete used in most construction work is reinforced with steel. When concrete structure members must resist compression stresses, steel supplies the necessary strength. Steel is embedded in the concrete in the form of a mesh, or roughened or twisted bars.

A bond forms between the steel and the concrete, and stresses can be transferred between both components. In This Project, there are three types of slabs: solid slabs, one-way ribbed and two way ribbed slab. They would be analyzed and designed by using finite element method of design, with aid of a computer Programs called " ATTIR and Safe - Software" to find the internal forces, deflections and moments for ribbed slabs.

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

NOTE:

*****Concrete B300, {f_c'= 24 MPa for rectangular and L section}.

*The specified yield strength of the reinforcement {fy = 420MPa}.

4.2 Factored load

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

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

4.3 Determination of slab thickness

Determination of Thickness for One Way Ribbed Slab:

According to ACI-Code-318-08, the minimum thickness of no pre-stressed beams or one-way slabs unless deflections are computed as follow:

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

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

=695 /18.5 = **37.56 cm**

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

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

= 600/21 = **28.57 cm**

Select Slab thickness **h= 35cm** with **block 27 cm** & **Topping 8cm.**

Load calculations:

One-way ribbed slab:

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

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

Parts of rib	Den..	Calculation
RC. Rib	25	0.27*0.14*25= 0.945 KN/m
Top Slab	25	0.08*0.54*25 = 1.08 KN/m.
Plaster	22	0.02*0.54*22 = 0.238 KN/m.
Block	10	0.4*0.27*10= 1.08 KN/m
Sand Fill	17	0.07*0.54*17= 0.643 KN/m
Tile	23	0.03*0.54*23 = 0.373KN/m
Mortar	22	0.02*0.54*22 =0.238KN/m.
partition	-	2*0.54 =1.08 KN/m

Nominal Total Dead load = **5.68 KN/m** of rib

Nominal Total live load =5*0.54=**2.7 KN/m** of rib

4.4 Design of topping

The calculation of the total dead load for the topping is shown below:

Table (4 – 2) Calculation of the total dead load on topping

No.	Material	Calculation
1	Tile	0.03*23*1= 0.69 KN/m
2	mortar	0.02*22*1= 0.44 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 *1 =2 KN/m
Sum		6.32 KN/m

W_u = 1.2 DL + 1.6 LL

= 1.2 * 6.32+ 1.6 * 5 = 15.58 KN/m^2. (Total Factored Load)

$$M_u = \frac{W_u * l^2}{12} = \frac{15.58 * 0.4^2}{12} = 0.208\, KN.m/m$$

$$\Phi M_n = 0.55 * 0.42\lambda\sqrt{f\acute{c}}\, S_m = 0.42 * 1 * \sqrt{24} * 1000 * \frac{80^2}{6} * 10^{-6} = 1.21\, KN.m \gg M_u = 0.208$$

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

$$\mathrm{As_{min}} = 0.0018 * 1000 * 80 = 144\, mm^2/\mathrm{m\ strip}$$

Try bars Φ8 with As = 50.27 mm^2

$$\mathrm{n} = \frac{144}{50.27} = 2.87 \text{ bars}$$

Select 5Φ8 / or Φ8@200 mm in both directions

4.5 Design of one way Ribbed slab

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

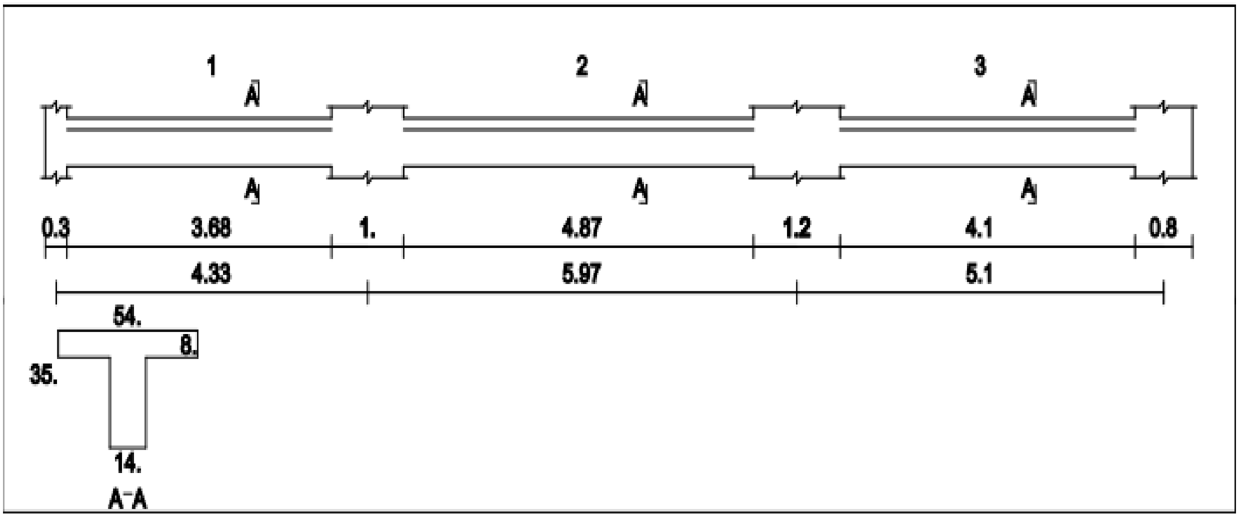


Figure 4- 2 Rib geometry

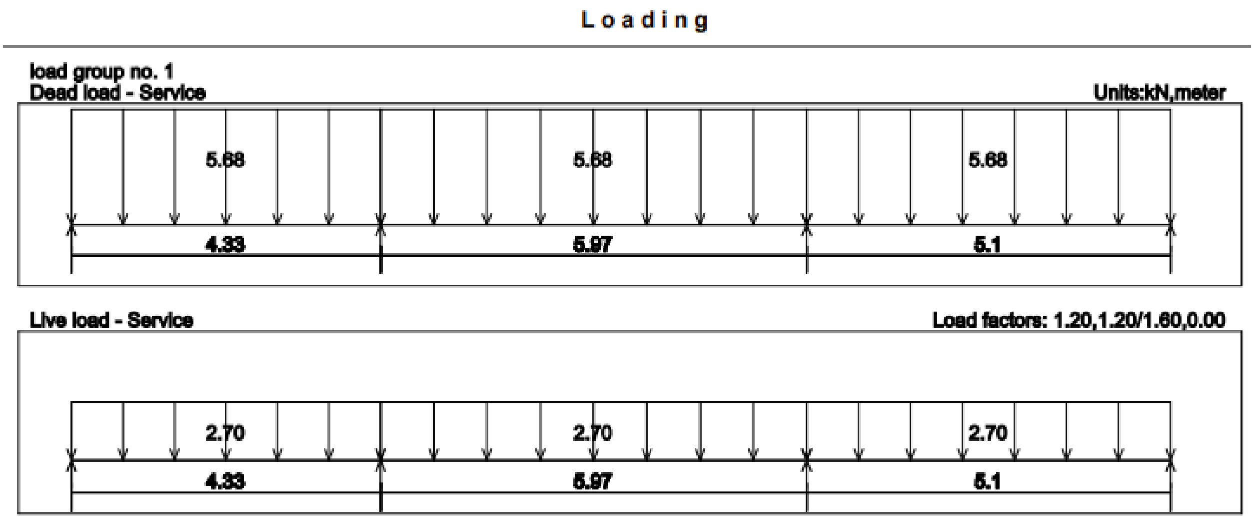


Figure 4- 3 Loads on rib R18

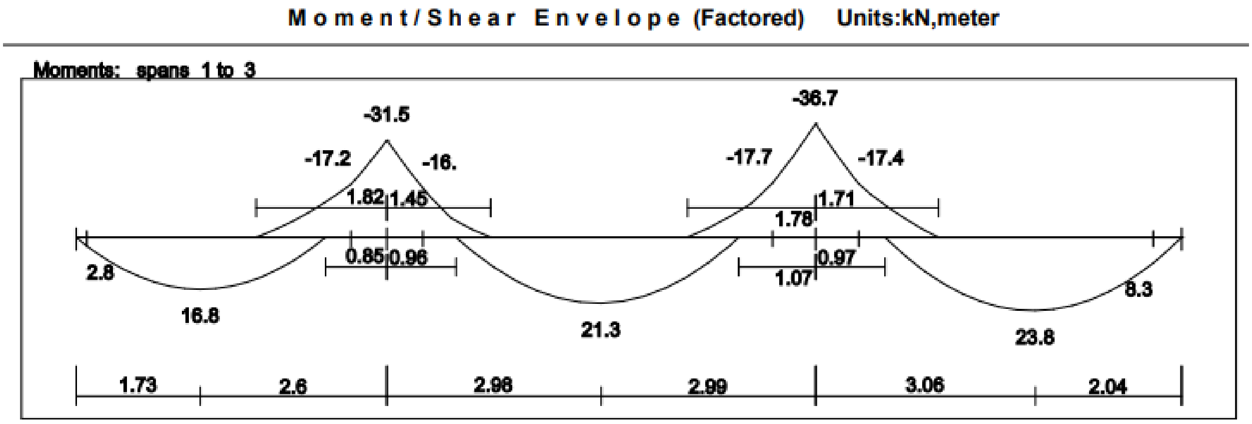


Figure 4- 4 Moment envelop for rib R18

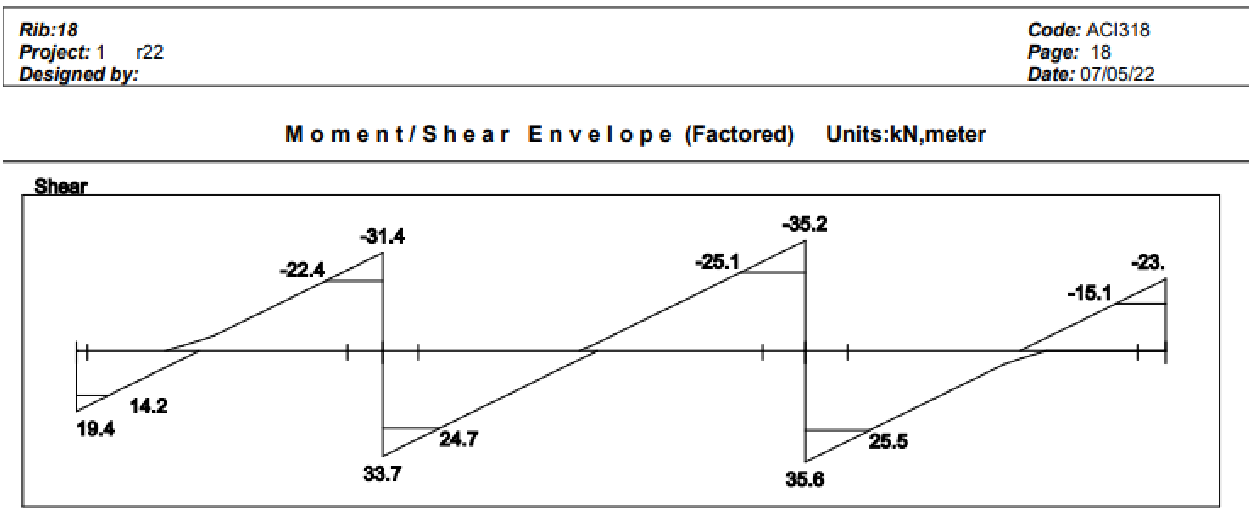


Figure 4- 5 Shear envelop for rib R18

4.5.1 Design of flexure: -

Design of Positive moment of rib (RIB 18):

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

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

→$M_{u\ max}$ = 23.8 KN.m

be ≤ Distance center to center between ribs = 540 mm………… Controlled.

≤ Span/4 = 5970/4 = 1492.5 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> $M_{u\ max}$= 23.8 KN.m.

∴ **DESIGN AS RECTANGULAR SECTION**.

1) Maximum positive moment $Mu^{(+)}$ **= 23.8 KN.m**

M_n = Mu /ϕ =23.8/ 0.9 = 26.44 KN.m

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

$$R_n = \frac{M_n}{b*d^2} = \frac{26.44*10^6}{540*(314)^2} = 0.496 \text{ MPa}$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.496*20.58}{420}}\right) = 0.0.0012$$

→A_s = ρ * b *d = 0.0012 * 540 * 314= 203.472 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_{min} = 146.53 mm^2<As_{req} = 203.472 mm^2.

∴ As = 203.472 mm^2.

2 Φ12 =226.2 mm^2>As_{req} = 203.472 mm^2. OK.

∴ Use 2 Φ12

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

Tension = Compression

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

226.2* 420 = 0.85 * 24 * 140 * a

a = 33.26 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{33.26}{0.85}$ = 39.13 mm.

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

$= \frac{314-39.13}{39.13} * 0.003$ = 0.0211 > 0.005 ∴ ϕ =0.9 … OK!

Maximum negative moment $Mu^{(-)}$ = 17.7KN.m

M_n = Mu /ϕ =17.7/ 0.9 = 19.67 KN.m

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

$R_n = \frac{M_n}{b*d^2} = \frac{19.67*10^6}{540*(314)^2}$ = 0.369 MPa

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.369*20.58}{420}}\right)$ = 0.00089

$\rightarrow A_s = \rho * b * d = 0.00089 * 140 * 314 = 39.12\ mm^2$.

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

$\rightarrow As_{min} = 146.53\ mm^2 \geq As_{req} = 39.12\ mm^2$.

$\therefore$ As = 146.53 mm^2.

2 Φ10 =157 $mm^2 > As_{req} = 146.53\ mm^2$. OK.

∴ Use 2 Φ10

4.5.2 Design of shear of rib (RIB 1):

1) Vu = 25.5 KN.

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

$= 1.1 * \frac{\sqrt{24}}{6} * 0.14 * 0.314 * 10^3 = 39.48$ KN.

$\phi V_c = 0.75 * 39.48 = 29.61$ KN.

→Check for Cases: -

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

$25.5 \leq \frac{29.61}{2} = 14.805$

∴ Case (1) is NOT satisfied

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

$14.805 \leq 25.5 \leq 29.61$

∴ Case (2) is satisfied → shear reinforcement is required.

<u>Try 2Φ8: -</u>

$\frac{100.5*420*314}{S}$ = 29.61*10^3 → S = 447.62 mm.

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

≤ 600 mm.

∴ **Use 2Φ8 @ 15 Cm**

4.6 Design of Beam 43

Material: -

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

Section: -

B = 100 cm

h =60 cm "choose h= 60 , for deflection requirments L/240"

According to ACI-Code-318-08, the minimum thickness of no prestressed beams or one way slabs unless deflections are computed as follow:

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

=871/21 = 41.48 cm.

→Select Total depth of beam **h=60cm. (35cm slab and 25 cm drop)**

Beam: 43
Project: 1 r22
Designed by:

Code: ACI318
Page: 29
Date: 07/05/22

G e o m e t r y Units:meter,cm

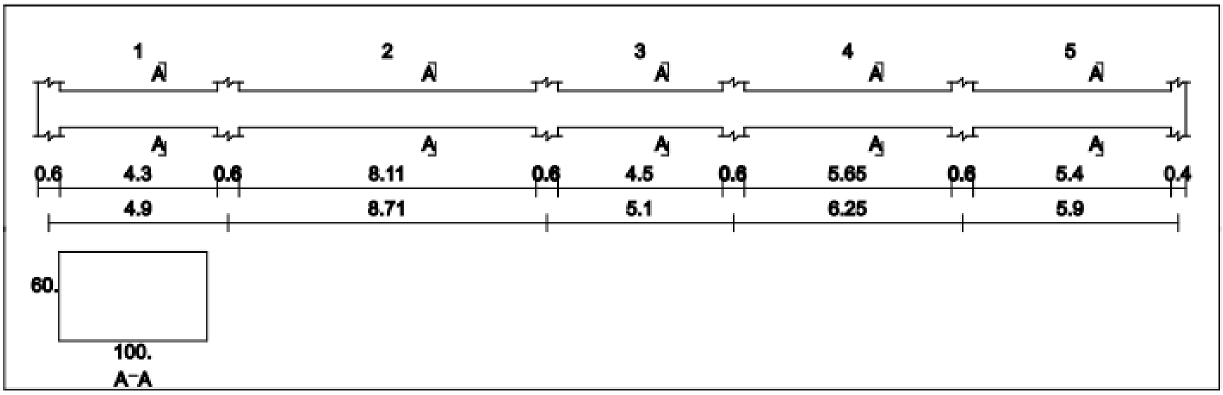


Figure 4- 6 Beam 43 Geometry

L o a d i n g

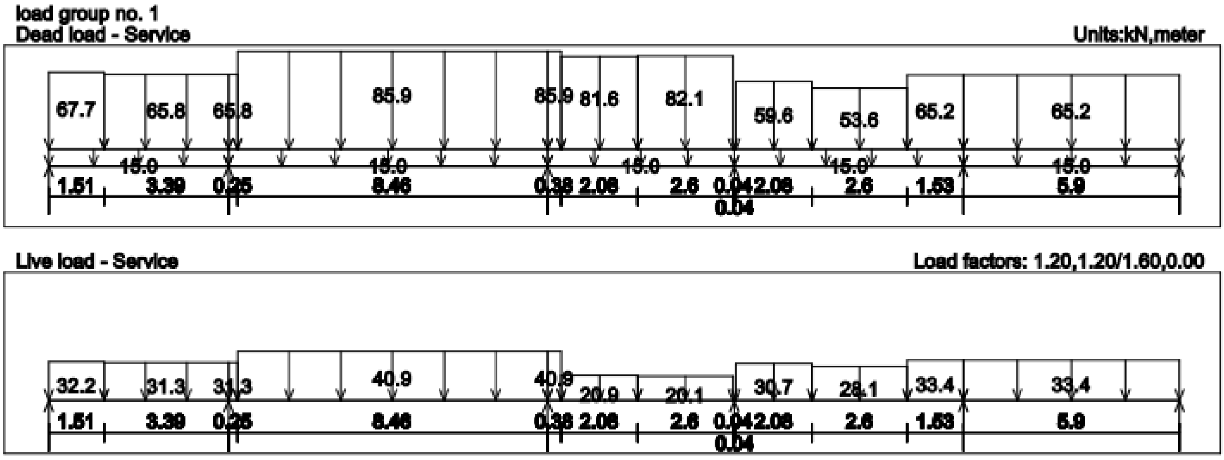


Figure 4- 7 Loads on Beam 43

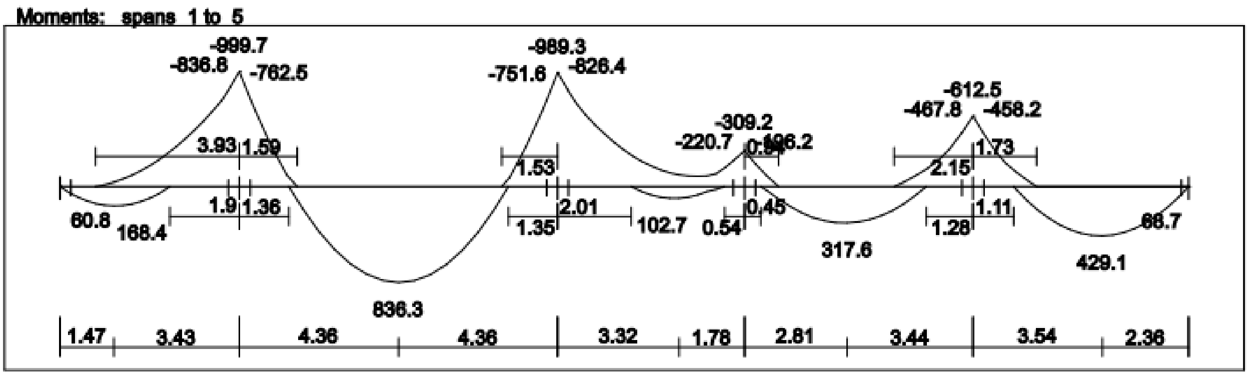


Figure 4- 8 Moment Envelop for Beam 43

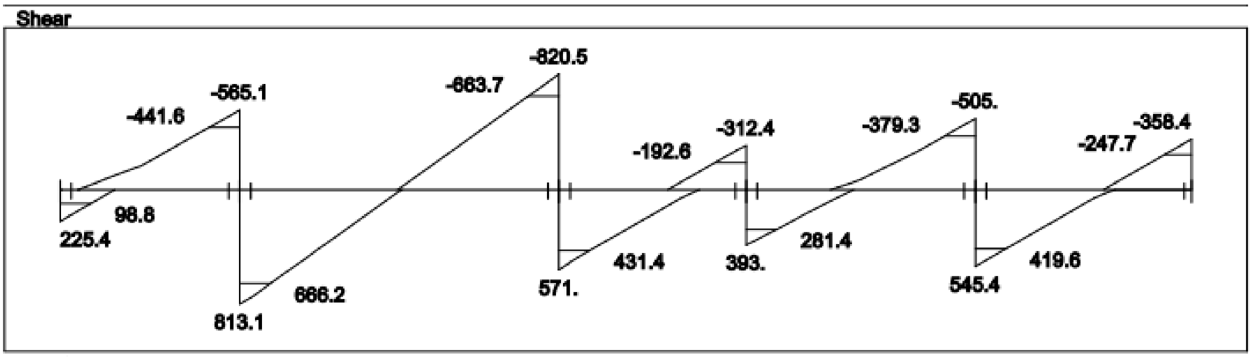


Figure 4- 9 Shear Envelop for Beam 43

4.6.1 Design of flexure: -

Design of Positive moment: -

→Mu_{max} =836.3 KN.m

b_w = 100 Cm.   h =60 Cm.

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

$=600 – 40 – 10 – \frac{20}{2} =540mm$

$C_{max} = \frac{3}{7} * d = \frac{3}{7} * 540=231.43mm.$

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

$a_{max} = \beta_1 * C_{max} = 0.85 * 231.43= 197mm.$

*Note:

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

$= 0.85 * 24 * 1 * 0.197* (0.540 – 0.197/2) * 10^3$

=1774.3 KN.m

$\epsilon_s = 0.004$

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

→$\phi Mn_{max} = 0.82 * 1774.3=1454.926$ KN.m

→ Mu = 836.3 KN.m< ϕMn_{max} 1454.926 KN.m

∴**Singly reinforced concrete section.**

1) Maximum positive moment *Mu* ⁽⁺⁾ = 836.3 KN.m

Mn = Mu /ϕ= 836.3/ 0.9 =929.22 KN.m .

→m=20.58

$R_n = \frac{M_n}{b*d^2} = \frac{929.22*10^6}{1000*(541)^2}$ =3.19 MPa

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

$\frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*3.19*20.58}{420}}\right)$=0.00831

$A_s = \rho$ * b *d =0.00831*1000*540=4487.4 mm^2

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

$$\frac{\sqrt{24}}{4*420} * 1000 * 540 \;\; \geq \; \frac{1.4}{420} * 1000 * 540$$

=1574.67mm^2<1800mm^2 …. Larger value is CONTROL

As= 4487.4 mm^2

Use Φ20…. As=314.16mm^2

#of bars= (4487.4/314.16) =15

∴ **Use 15 Φ20…As=4712.4** > 4487.4mm^2

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

Tension = Compression

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

4712.4* 420 = 0.85 * 24 * 1000* a

a = 97.02 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{97.02}{0.85}$ = 114.14 mm.

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

$= \frac{540-114.14}{114.14}$ * 0.003 = 0.0112 > 0.005 ∴ ϕ =0.9 … OK!

4.6.2 Design of shear: -

1) Vu = 666.2 KN .

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

$= 0.75 * \frac{\sqrt{24}}{6} * 1000 * 540 * 10^{-3}$ = 330.68KN.

\→ **Check For Cases:-**

1- <u>Case1 :</u>

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

$666.2 \leq \frac{330.68}{2} = 165.34$

∴ Case (1) is NOT satisfied

<u>Case 2 :</u>

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

165.34 <666.2≤330.68

∴ Case (2) is NOT satisfied

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

ϕ Vs $_{min}$ $\geq$ $\frac{\phi}{16}\sqrt{f_c'}$ * b_w * d = $\frac{0.75}{16}\sqrt{24}$ * 1 *0.540 * 10^3 =124KN.

$\geq$ $\frac{\phi}{3}$ * b_w * d = $\frac{0.75}{3}$ * 1 * 0.540 * 10^3 = 135KN …. CONTROL.

∴ϕVs $_{min}$ = 135 KN.

ϕV_c + ϕVs $_{min}$ = 330.68+ 135=465.68KN.

$\phi V_c <$ V_u $\leq$ ϕV_c + ϕVs $_{min}$

330.68<666.2≤ 465.68

∴ **Case (3) is NOT satisfied**

<u>4.case(4):</u> ϕV_c + ϕVs $_{min}$ ≤ v_u ≤ $\phi(v_c+v_s`)$

Vs`=$\frac{1}{3}\sqrt{f_c}$ *bw*d

Vs`=$\frac{1}{3}\sqrt{24}$*1000*540*10$^{\wedge-3}$ = 881.816KN

ϕV_c + ϕVs $_{min}$ ≤ V_U ≤ $\phi(v_c+v_s`)$

465.68 ≤ 666.2 ≤ 881.81 OK

Case (4) is satisfied

<u>Try 2Φ10</u> =2 * 78.5 = 157 mm^2.

$\frac{2*78.5*}{S} = \frac{420*540*11.68 * 10^{-3}}{180}$ ⟶ s = 1471.68mm

s ≤ $\frac{d}{2} = \frac{540}{2}$ = 270 mm …. CONTROL

≤ 600 mm.

∴ **Use Φ10 @ 20Cm 2L.**

4.7 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*7.03+2*6.84)/180=15.14 cm

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

2. accurate method:

All exterior and interior beams have a rectangular section of 60 width and 60cm depth:

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

$$\text{I for beam} = \frac{60 * 60^3}{12}$$

=1080000 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=6.84 m =684cm

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

$$Is = \frac{87007.51 * (\frac{684}{2} + 60)}{54}$$

=647722.57cm^4

Long direction L=7.03m=703 cm

$$Is = \frac{87007.51 * (\frac{703}{2} + 60)}{54}$$

663029.45 cm^4=

Short direction l_{right}=l_{left} =6.84 m=684 cm

Slab section for interior beam

Long direction l_{left}=l_{right} =7.03m=703cm

$$Is = \frac{87007.51 * (\frac{703}{2} + \frac{684}{2} + 60)}{54}$$

=1214077.015cm^4

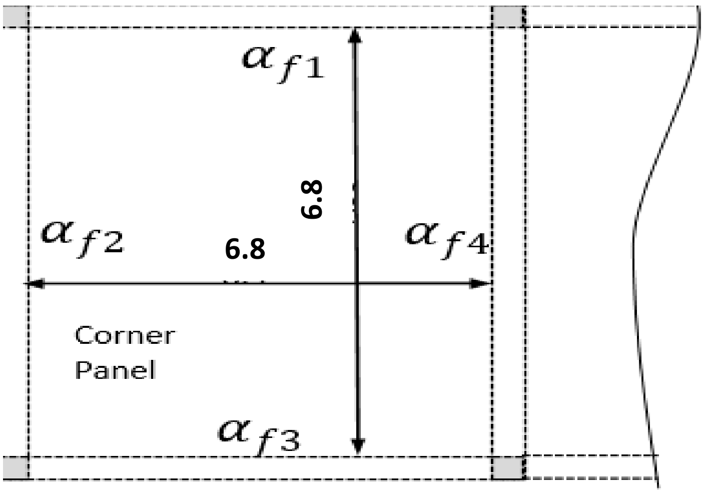


Figure 4- 10 Two way rib case

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

α1=1080000/1214077.015=0.889

α2=1080000/647722.57=1.667

α3=1080000/663029.45 =1.628

α4=1080000/1214077.015=0.889

αfm=(0.889+1.667+1.628+0.889)/4

= 1.268 <2.0 the minimum slab thickness will be :

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

$$h = \frac{8400(0.8 + \frac{420}{1400})}{36 + 5 * 1.06(1.268 - 0.2)}$$

=287.15 mm>125mm

β=7.03/6.84=1.03

First trial thickness h=350mm >287.15 mm_ok

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

Load calculation:

Material	Quality Density KN/m^3	$W = \gamma \cdot V$ KN
Tiles	23	$23\times 0.03 \times 0.54 \times 0.54 = 0.201$
mortar	22	$22 \times 0.02 \times 0.54 \times 0.54 = 0.128$
Sand	17	$17\times 0.07 \times 0.54 \times 0.54 = 0.643$
Reinforced Concrete Topping	25	$25 \times 0.08 \times 0.54 \times 0.54 = 0.583$
Reinforced Concrete Rib	25	$25\times 0.27 \times 0.14 \times (0.54 + 0.4) = 0.882$
Concrete Block	12	$12 \times 0.27 \times 0.4 \times 0.4 = 0.518$
Plaster	22	$22 \times 0.02\times 0.54 \times 0.54 = 0.122$
For ceiling	1.25	$1.25 \times 0.54\times 0.6\times 0.54 = 0.22$
Partitions 2 KN/m^2		$2\times 0.54 \times 0.54 = 0.583$
Total Dead Load, KN		3.98

$$DL = \frac{3.98}{0.54 \times 0.54} = 13.65 \text{ KN/m2}$$

$$W_D = 1.2 \cdot 13.65 = 16.38\ KN/m^2$$

Live Load of slab:

$LL = 5\ KN/m^2$

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

$w = 13.54 + 8 = 21.54\ KN/m^2$

Moments calculations:

$$M_a = C_a w l_a^2 \quad \text{and} \quad M_b = C_b w l_b^2$$

La/Lb = 1

Design of bending moment:

Ma,pos ,DL=0.027*16.38*6.8^2

= 20.45 KN.m/m

Mb,pos ,DL=0.018*16.38*6.8^2

= 13.63 KN.m/m

Ma,pos,LL=0.032*8*6.8^2

=11.84 KN.m/m

Mb,pos,LL=0.032*8*6.8^2

=11.84 KN.m/m

Ma,pos =16.90+11.84=28.74 KN.m/m

Mb,pos =11.27+11.84=23.11 KN.m/m

Mb,neg =Ma.neg=0.05*21.54*6.8^2=49.8 KN.m/m

Design of positive moments:-

Mu=28.74 KN.m

ØMn =Mu

Mn=28.74/0.9=31.9 KN.m

Assume bar diameter Ø18 for main reinforcement

d=350-20-8-18/2=313mm

Rn=Mn/(b*d^2)

$=31.9/(540*313^2)$

=0.603 Mpa

m=fy/(0.85 fc)

=(420/.85*24)

=20.58

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

$$= \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.603*20.58}{420}}\right)$$

=0.00146

As=0.00146*540*313=246.77 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 = 246.77 mm2

∴As = 246.77 mm2 …. control

2Φ14= 308 mm2 > Asreq = 246.77mm2 OK

∴ Use 2 Φ14

Check for strain:

($\varepsilon_s \geq 0.005$)

Tension = Compression

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

308 * 420 = 0.85 * 24 * 540 * a

a = 11.75 mm

fc' = 24 MPa< 28 MPa→ β = 0.85

c=a/β = 11.75/0.85 = 13.82 mm

ε_s=(d-c)/c * 0.003

∴ ϕ =0.9 0.065 > 0.005 Ok

Design of negative moments:-

Mu=49.8 KN.m

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

=49.8 /0.9=55.3 KN.m

Assume bar diameter Ø16 for main reinforcement

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

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

=55.3*10^6/(540*$314^{2)}$

=1.04 Mpa

`

m=420/(0.85*24)=20.58

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

$$=\frac{1}{20.58}(1 - \sqrt{1 - \frac{2*1.04*20.58}{420}})$$

=0.0025

As=0.0025*140*314=109.9 mm^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 = 109.9mm2

∴ As = 146.53 mm2 control

2Φ12 = 226.2 mm2 > Asreq = 146.53mm2 OK

∴ Use 2 Φ12

Check for strain: (ε_s≥0.005)

Tension = Compression

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

226.2 * 420 = 0.85 * 24 * 540 * a

a = 8.624 m

fc'= 24 MPa< 28 MPa→ β = 0.85

c=a/β = 8.624/0.85 = 10.15 mm

εs =(d-c)/c * 0.003

Ok 0.089 > 0.005

∴ ϕ =0.9

Design of shear:

W_b= 0.5

The total load on the panel being =(6.8*6.8*21.54=996 KN

The load per rib at the face of short beam is

(0.5*996*0.54)/(2*6.80)=19.77KN

V_{ud} =Vu_{face}-(Wu*bf*d)=19.77-(21.54*0.54*0.313)=16.13 KN

The maximum shear force at the distance d from the face of support, Vu = 16.13 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

32.82 < 29.5/2 =14.75 ∴ Case (1) is not satisfied

Case2: Vu ≤ (ϕVc)

29.5/2=14.75<16.13 < 29.5 OK

∴ Case (2) is satisfied

∴ 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} = 16.13 KN.

Try 2Φ8: -

$\frac{100.5*420*313}{S} = 16.13*10^3 \rightarrow S = 819.6$mm.

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

≤ 600 mm. ∴ **Use 2Φ8 @ 15 Cm**

4.8 Design of column (C5)

Calculation of Loads act on Column (C5)

Loads acting on columns are obtained from support reaction when analyzing the system on etabs

Dead Load = 3250 KN (service)

Live Load = 1150 KN (service)

Loads acting on column (C5) are as follows:

Factored loads (Pu) = 5740 KN

Calculation of Required Dimension of Column (C5)

Total load Pu = 5740 KN

Pn = 5740 /(0.65) = 8830.77 KN

$\rho g = 2.0\ \%$

$\mathrm{Pn} = 0.8 * \mathrm{Ag}\{0.85 * \mathrm{fc}' + \rho\mathrm{g}(\mathrm{fy} - 0.85\mathrm{fc}')\}$

$8830.77 * 10^{-3} = 0.8 * \mathrm{Ag}[0.85 * 24 + 0.02 * (420 - 0.85 * 24)]$

$\mathrm{Ag} = 3888\ cm^2$

∴**Select 60*60cm with Ag = 3600 cm².**

- **Check Slenderness Effect :**

For braced system if $\lambda \le 34 - 12\frac{M1}{M2} \le 40$, then column is classified as short column and slenderness effect shall not be considered.

$$\lambda = \frac{Klu}{r}$$

Lu: Actual unsupported (unbraced) length = 3.65 m

K: effective length factor (K= 1 for braced frame).

R: radius of gyration → for rectangular section = $\sqrt{\frac{I}{A}}$ 0.3 h

System about X

$\rightarrow \lambda = \frac{1 * 3.15}{0.3 * 0.6} = 17.5$

$\lambda \leq 34 - 12(1) = \mathbf{22} \leq 40$

$\lambda = 17.5 < 22$ ∴ Short about X and Y .

System about Y

$\rightarrow \lambda = \frac{1 * 3.15}{0.3 * 0.6} = 17.5$

$\lambda \leq 34 - 12(1) = \mathbf{22} \leq 40$

∴ Column is Short , So Slenderness effect will not be considered.

Calculation of Required Reinforcement Ratio

Since Column is short and slenderness effect will not be considered, then Design Strength of column can be calculated using the following equation :

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

Where , Pu = 5740 KN

$5740 * 10^3 = 0.65 * 0.8 * 600 * 600\{0.85 * 24 + \rho(420 - 0.85 * 24)\}$

$\Rightarrow \rho_g = 0.0257 > \rho_{min} = 0.01 \ \& < \rho_{max} = 0.08$

As req = 0.0257 *600 *600 =9252 mm^2

Use Φ 25 >> $\# \, of \, bar = \frac{9252}{490.63} = 18.86$

∴ **Use 20 Ø 25 with As = 9812.5 mm^2 >As_{req} = 9252 mm^2**

- **Check spacing between the bars :**

S = $\frac{600-2*40-2*10-6*25}{5} = 70 \, mm$

S = 76 mm $\geq 40mm$

$\geq$ 1.5db = 37.5 mm

Determination of Stirrups Spacing

According to ACI :

$\text{Spacing} \leq 16 \times d_b (\text{Longitudinal. bar. diameter}) = 16 \times 1.8$

$= 28.8 \text{ cm.}$

$\text{Spacing} \leq 48 \times d_t (\text{tie. bar. diameter}) = 48 \times 1.0 = 48\text{cm.}$

$\text{Spacing} \leq \text{Least. dim e nsion} = 40 \text{ cm}$

∴ **Select Ø 10/20cm**

Column (C5) Section is shown in figure(4-11) where bars arrangement and stirrups detailing appear :

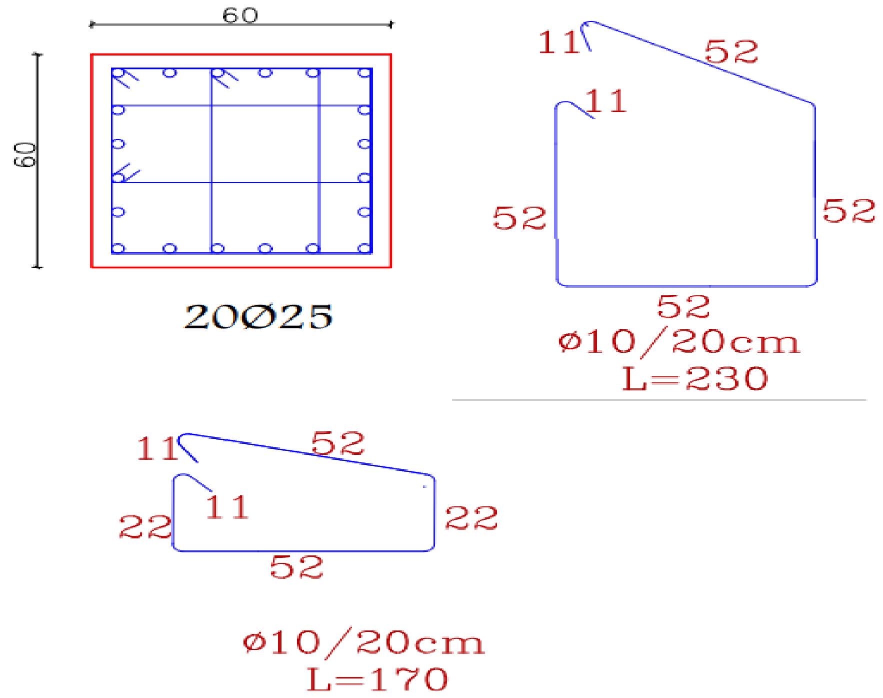


Figure 4- 11 Column C5 detailing

4.9 Design of Isolated Footing (F5)

Loads that act on footing F5 are :

- PD =3250 kN , PL = 1150 kN
- Pu = 1.2 * 3250 + 1.6*1150 = 5740 kN

The following parameters are used in design :

- γ_{concrete} = 25 kN/m^3
- γ_{soil} = 18 kN/m^3
- σ_{allow} = 500 kN/m^2
- clear cover = 5 cm

Determination of footing dimension (a)

Footing dimension can be determined by designing the soil against bearing pressure .

→ Assume h = 75 cm

→ $\sigma_{b(allow)\text{net}}$ = 500 – 25*0.75 – 0.25*18 - 5 = 471.75 kN/m²

→ $A = \frac{P_n}{q_{a.net}} = \frac{3250+1150}{471.75} = 9.3\ m^2$

→ $l = \sqrt{A} = \sqrt{9.3} = 3.05\ m$

→ Select $l = 3.1\ m$

Determination of footing depth (h)

To determine depth of footing both of one and two way shear must be designed.

→ $q_u = \frac{P_u}{A} = \frac{5740}{9.61} = 597.3\ KN/m^2$

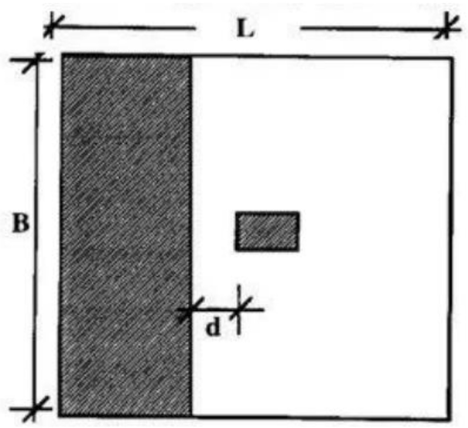


Figure 4- 12 One way shear

Design of one way shear

$d = \text{h} - cover - \emptyset = 750 - 50 - 16 = 684mm$

→ Vu at distance d from the face of column

$V_u = q_u b(\frac{l}{2} - \frac{a}{2} - d)$

$= 597.3 * 3.1\left(\frac{3.1}{2} - \frac{0.6}{2} - 0.684\right) = 1048\ KN$

$\emptyset$ Vc = $0.75 * \frac{1}{6} * \sqrt{fc'} * b * d$

= $0.75 * \frac{1}{6} * \sqrt{28} * 3100 * 684$ =1402.5 kN >Vu

∴ **h = 75 cm is correct** ✓

Design of Punching (two way shear)

→ d = 684 mm

→ b_o = 4(0.6+0.684) = 5136 mm

→ Bc = 1

→ αs = 40 (interior column)

Vu = 597.3(3.1*3.1-(0.6+0.684)(0.6+0.684)) = **4560 kN**

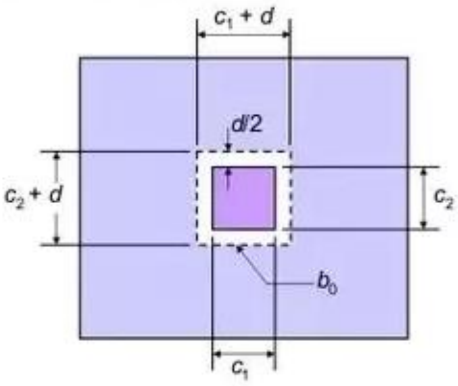


Figure 4- 13 Two way Shear (Punching)

ØVc is the smallest of :

1. $Vc = \frac{1}{6}\left(1+\frac{2}{\beta}\right) \times \sqrt{fc} \times b_o \times d$

$= \frac{1}{6}\left(1+\frac{2}{1}\right) \times \sqrt{28} \times 5136 \times 684 \times 10^{-3} = 9294.6KN$ ∢ **cont.**

2. $Vc = \frac{1}{12}\left(\frac{\alpha_s \times d}{b_o} + 2\right) \times \sqrt{fc} \times b_o \times d$

$= \frac{1}{12}\left(\frac{40 \times 684}{5136} + 2\right) \times \sqrt{28} \times 5136 \times 684 \times 10^{-3} = 11350.4\ KN$

3. $Vc = \frac{1}{3} \times \sqrt{fc} \times b_o \times d$

$= \frac{1}{3} \times \sqrt{28} \times 5136 \times 684 \times 10^{-3} = 6196.4\ kN$

→ ØVc = 0.75 × 6196.4 = **4647.3** kN > Vu = **4560** kN

∴ **h = 75 cm is correct ✓**

Design of Reinforcement

Mu = 597.3 *1.25*3.1*(1.25/2) = 1446.6 kN.m

→ $m = \frac{Fy}{0.85*Fc'} = \frac{420}{0.85*28} = 17.64$

→ Mn = 1446.6/0.9 = 1607.3 kN.m

→ $Rn = \frac{Mn}{b*d^2} = \frac{1607.3*10^6}{3100*684^2}$ = 1.1 MPa

$\rightarrow \ \rho = \frac{1}{m} * (1- \sqrt{1 - \frac{2*Rn*m}{Fy}})$

$= \frac{1}{17.64} * (1- \sqrt{1 - \frac{2*1.1*17.64}{420}}) = 0.0026$

$\rightarrow$ Asreq = $\rho * b * d = 0.0026 * 3100 * 684 = 5688$ mm^2

$\rightarrow$ As (min) = 0.0018*b*h = 0.0018*3100 * 750 = 4185 mm^2

$\rightarrow$ Asreq > As (min)

∴ **Select for both directions: 29Ø16 with As = 5827.8 mm^2 > Asreq … (ok)**

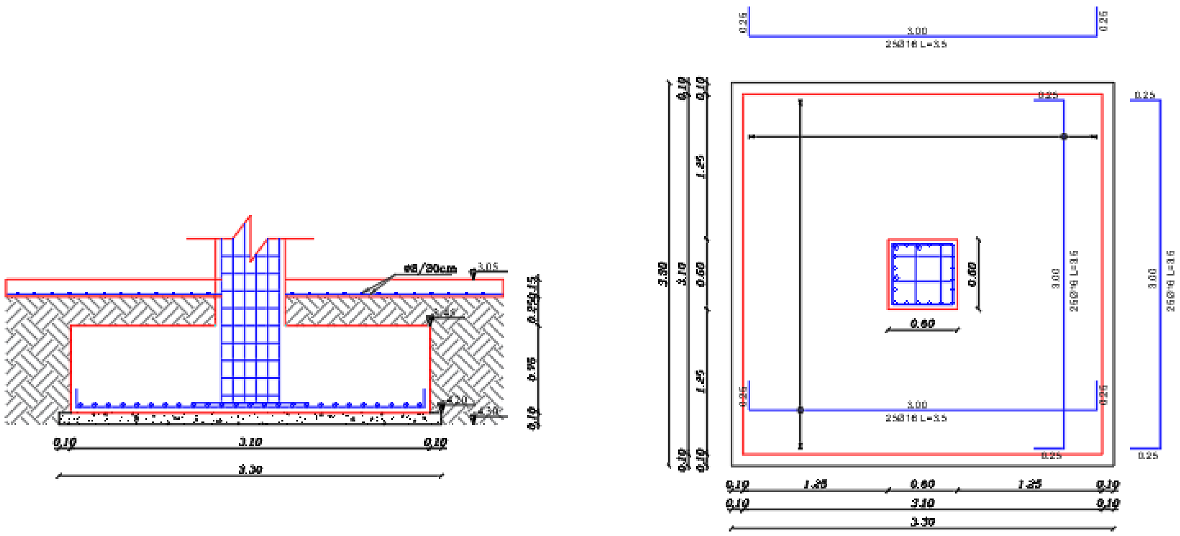


Figure 4- 14 Foundation F5 Reinforcement

4.10 Design of Stairs

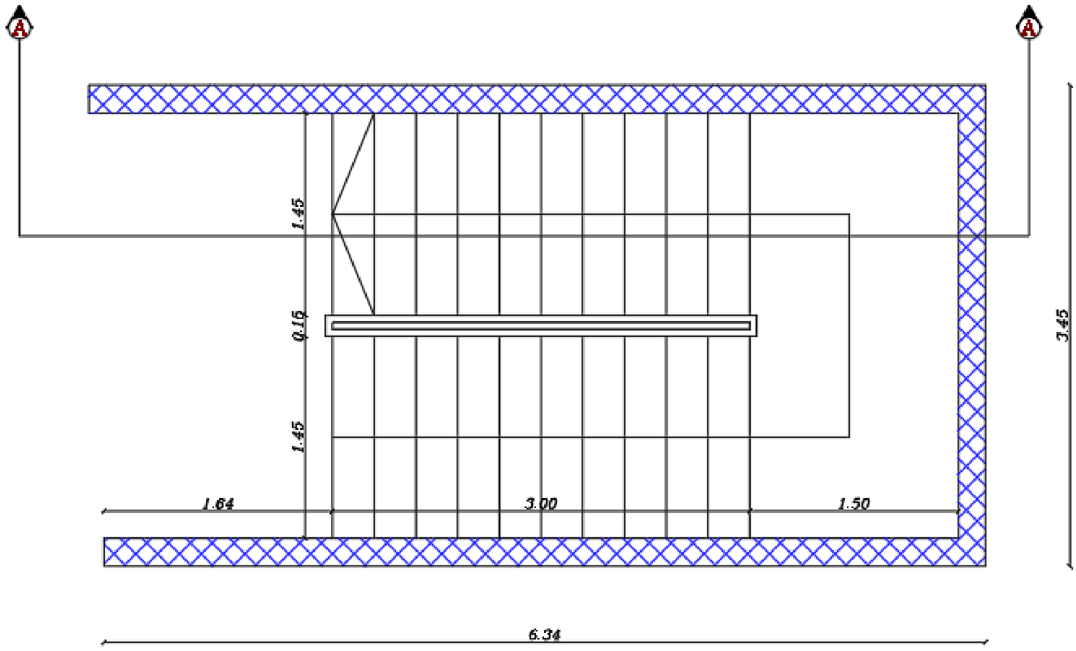


Figure 4- 15 Stair

Design of flight

The structural system of the flight is shown in figure (4-22) and the following steps explain the design procedure of the flight :

1. **Determination of flight thickness :**

   Limitation of deflection: h ≥ minimum h

   h (min) = L/20 = 320/20 = 16cm

   ∴ Select h = 15 cm, but shear and deflection must be checked

   Angle (α): tan(α) = 16/30 → α = 28.1°

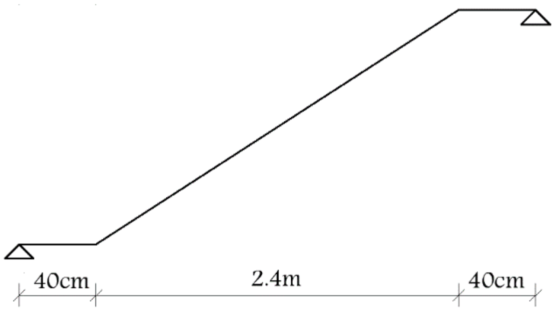


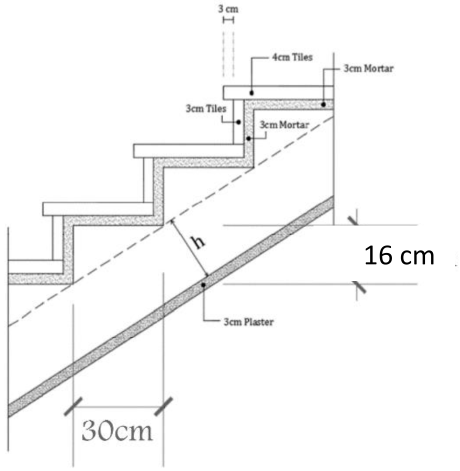
Figure 4- 16 Structural System of flight

2. Loads calculation :

Figure (4-23) shows a section in the flight in which the layers carried by the flight appear.

Table(4- 1): Calculation of Dead Loads that act on Flight

Flight Dead Loads
Flight = (0.15 * 25*1)/ cos(28.1) =4.25 kN/m
Plaster = (0.03 * 22*1)/ cos(28.1) =0.75 kN/m
Hor.Mortar =0.03*22*1 =0.66 kN/m
Ver.Mortar = 0.03*22*($\frac{0.16}{0.3}$) = 0.352 kN/m
Hor.Tiles = 0.04*23*($\frac{33}{30}$) = 1 kN/m
Ver.Tiles = 0.03*23*($\frac{0.16}{0.3}$) = 0.368 kN/m
Triangle =0.5*0.16*25 =2 kN/m
Sum=9.4 kN/m



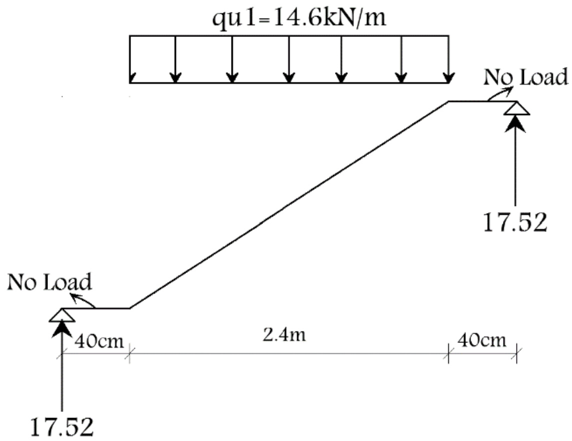
Factored Load

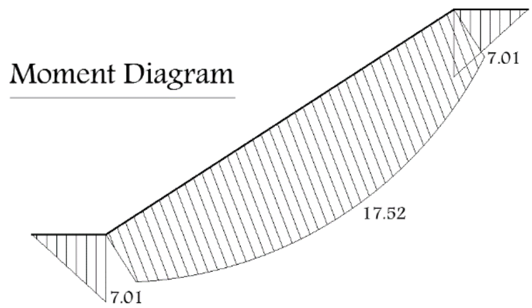
qu= 1.2 *9.4 + 1.6*2 = 14.6 kN/m

Vu= 14.6*2.4/2 = 17.52 kN

3. Analysis :

The following figures show shear and moment Diagrams resulted from analysis of the flight :





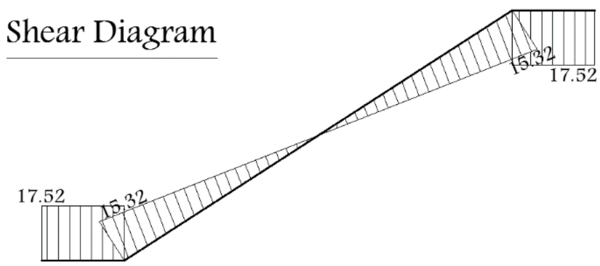


Figure 4- 17 Anlaysis of flight

4. Design :

- **Design of Shear Force :**

d=150-20-(12/2) = 124 mm

$Ø \times Vc = 0.75 * \frac{1}{6} * \sqrt{Fc'} * bw * d$

$= 0.75 * \frac{1}{6} * \sqrt{24} * 1000 * 124$

$= 75.9$ kN > Vu max = 15.32 kN

∴ No Shear Reinforcement is Required#

- **Design of Bending Moment :**

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

$\rightarrow$ $Rn = \frac{Mu/Ø}{b*d^2} = \frac{\mathbf{17.4}*10^6/0.9}{1000*124^2} = 1.26$ MPa

$\rightarrow$ $\rho = \frac{1}{m} * (1- \sqrt{1 - \frac{2*Rn*m}{Fy}}) = \frac{1}{19.6} * (1- \sqrt{1 - \frac{2*1.26*20.6}{400}}) = 0.0031$

$\rightarrow$ $Asreq = \rho * b * d = 0.0031 * 1000 * 124 = 384.4 \text{ mm}^2$

$\rightarrow$ As min = 0.0018 *1000*16.7 = 300.6 mm^2

∴ Select **Ø12/20 with As = 565 mm^2** > As req …. For Main Reinforcement

For secondary Reinforcement select **Ø10 /20 with As=395 mm^2** = As min

$\rightarrow$ Check Spacing :

20cm < **S max** = 3 * 15 = **45 cm … ok**
< **45 cm**

$\rightarrow$ Check Strain:

C = T

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

0.85*24*a*1000 = 300.6 *420

a = 5.89 mm $\rightarrow$ c = a/β = 5.89/0.85 = 6.18 mm

$\varepsilon_s = \frac{0.003*d}{c} - 0.003 = \frac{0.003*124}{6.18} - 0.003$

∴ **ε_s = 0.057 > 0.005 …. Ø = 0.9 (OK)**

Design of Landing

The structural system of the landing is shown in figure (4-25) and the following steps explain the design procedure of it :

Figure 4- 18 Structural System of landing

- **Determination of Landing thickness :**

  Limitation of deflection:

  h ≥ minimum h

  h (min) = L/20 = 305/20 = 15.25 cm

  ∴ Select h = 15 cm , but shear and deflection must be checked

- **Loads calculation :**

  Figure (4-26) shows a section in the landing in which the layers carried by the landing appear.

Table(4- 2):Calculation of Dead Loads that act on Landing

Landing Dead Loads
Tiles = 0.03*23*1=0.7 kN/m
Mortar = 0.03*22*1=0.4 kN/m
Sand = 0.07*16*1=1.1 kN/m
Slab = 0.15*25*1=3.75 kN/m
Plaster = 0.02*22*1=0.4 kN/m
Sum = 6.35 kN/m

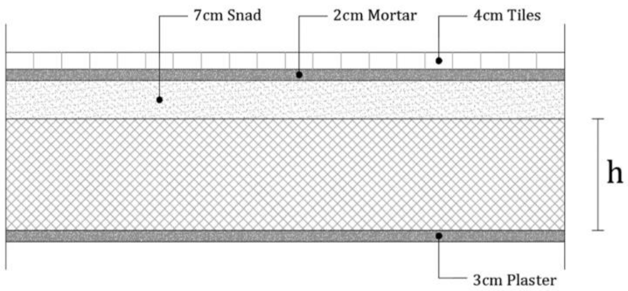


Figure 4- 19 Section in the landing

Factored Loads :

qu = 1.2*6.35+1.6*2 = 10.82 kN/m

The landing carries (dead load & live load of landing + support reaction resulted from the flight)

qu = 10.82 + Support reaction of flight = 10.82 + 17.52 = **28.34 kN/m**

→ **Analysis :**

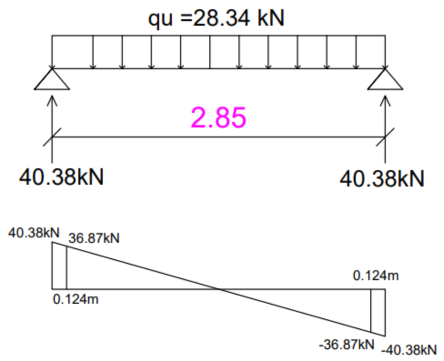


Figure 4- 20 Analysis of landing

d= 150-20-(12/2) = 124mm

Vumax= 40.38 – (28.34*0.124) = **36.87 kN**

Mu max = $\frac{28.34*2.85^2}{8}$ = **28.77 kN.m**

Shear Force Design :

d=124mm & Vu max=36.87 kN

$\emptyset \times Vc = 0.75 * \frac{1}{6} * \sqrt{24}$ * 1000 * 124=75.9kN > Vu max = 36.87 kN

∴ No Shear Reinforcement is Required #

→ **Bending Moment Design : (Mu max = 28.77 kN.m)**

- m = 20.6
- Rn = $\frac{28.77 \ *10^6/0.9}{1000*124^2}$ = 2.08 MPa
- $\rho = \frac{1}{20.6} * (1- \sqrt{1 - \frac{2*2.08*20.6}{420}}) = 0.00523$
- Asreq = $0.00523 * 1000 * 124 = 649.1$ mm^2
- As min = 0.0018 *1000*150 = 270 mm^2

∴ Select **Ø12/15cm with As = $\frac{\pi*14^2}{4} * \frac{100}{15}$ = 753 mm^2** > As req …. For Main Reinforcement

- Check Spacing :
  15cm < **S max** = 3 * 15 = **45 cm … ok**
  < 45cm

- Check Strain:
  C = T
  0.85*fc'*a*b = As*fy

$$0.85*24*a*1000 = 753 *420$$

$$a = 15.5 \text{ mm} \rightarrow \quad c = a/\beta = 15.5/0.85 = 18.24 \text{ mm}$$

$$\varepsilon_s = \frac{0.003*(124-18.24)}{18.24}$$

$$\therefore \ \boldsymbol{\varepsilon_s = 0.0174 > 0.005 \ \ldots\ \text{Ø} = 0.9 \ (\text{OK})}$$

The following figure shows section A-A of the stairs in which reinforcement detailing appears .

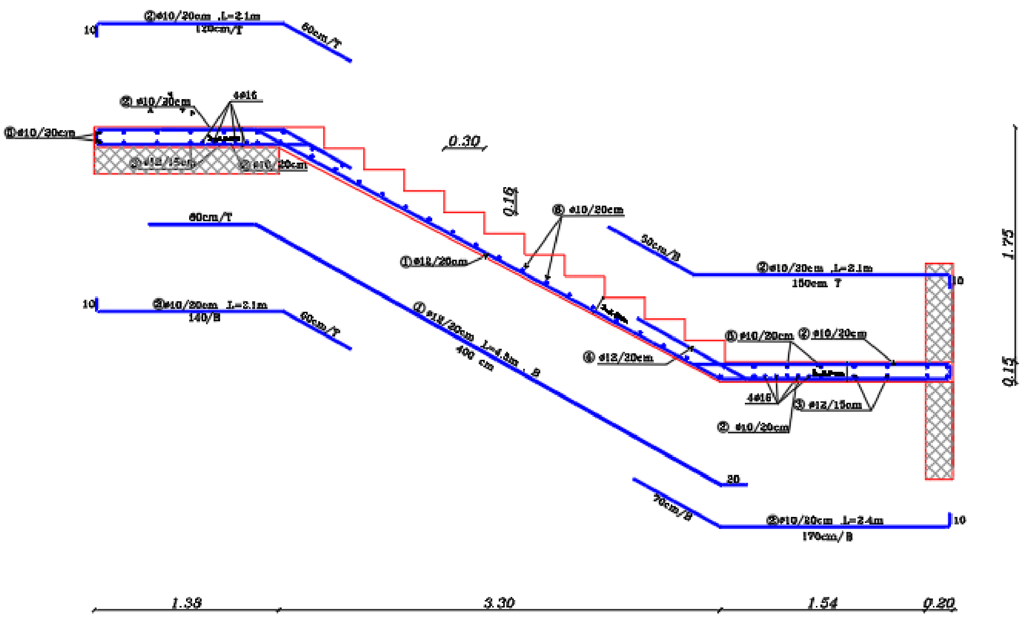


Figure 4- 21 Stair reinforcement

4.11 Design of shear wall

Analysis and design were done using ETABS program in which the seismic loads were taken into account. The following is a sample calculation for one of the walls, S.W12.

The following data that used in design**:**

- Shear Wall thickness = h = 25 cm
- Shear Wall length Lw = 6.0m
- Building height Hw=18.9 m
- Critical section shear :

Lw/2=6/2=3 ….. control

hw/2=18.9/2=9.5

story height=3.15

→ d =0.8*Lw =0.8*6.0 = 4.8 m

4.11.1 Design of Horizontal Reinforcement

Calculation of Shear Strength Provided by concrete Vc:

- Shear Strength of Concrete is the smallest of :

1- Vc = $\frac{1}{6}\sqrt{fc'} \times b \times d$

= $\frac{1}{6}\sqrt{24} \times 250 \times 4800 = \mathbf{979.8\ kN} \ll \text{Controlled}$

2- Vc = $0.27\sqrt{fc'} \times h \times d + \frac{Nu \times d}{4Lw}$

= $0.27\sqrt{24} \times 250 \times 4800 + 0 = 1587.3\ KN$

3- $Vc = \left[0.05 * \sqrt{fc'} + \frac{Lw\left(0.1\sqrt{fc'}+0.2\frac{Nu}{Lw.h}\right)}{\frac{Mu1}{Vu} - \frac{Lw}{2}}\right] \times h \times d$

Where:

- Mu1= 920.5 kN.m

- $\frac{Mu1}{Vu} - \frac{Lw}{2} = \frac{920.5}{750.3} - \frac{6}{2} = -1.77 < 0$ → This equation is not applicable.

∴ $Vc = 979.8$ kN → $\emptyset Vc = 734.85 < Vumax^1 = 750.3$ kN →Horizontal Reinforcement is Required.

$\rightarrow Vs = \frac{Vu}{\emptyset} - Vc = \frac{750.3}{0.75} - 979.8 = 20.6$ kN

$\rightarrow \frac{Avh}{s} = \frac{Vs}{fy*d} = \frac{20.6*10^3}{420*4800} = 0.0102$

but $\left(\frac{Avh}{s}\right)\min = 0.0025 * h = 0.0025 * 250 = \mathbf{0.625} \ll$ Controlled.

→ Avh : For 2 layers of Horizontal Reinforcement

Select Ø10 :

Avh = 2 *79 = 158 mm^2

$\frac{Avh}{s} = 0.625 \rightarrow Sreq = \frac{158}{0.625} = 252.8\, mm$

Smax= Lw/3 = 6000/3 = 2000 mm

= 3h = 3*250 =750mm

$= 45cm \ll$ Controlled.

∴**<u>Select Ø10 @ 200 mm at each side.</u>**

4.7.2 Design of Vertical Reinforcement

$\rightarrow$ Avv = [0.0025 +0.5 (2.5-$\frac{hw}{lw}$)($\frac{Avh}{Shor*h} - 0.0025)] * h * Sver$

$$\frac{hw}{lw} = \frac{28}{6} = 4.667 > 2.50$$

$\rightarrow$ $\frac{Avv}{Sver}$ = [0.0025 +0.5 (0)($\frac{2*79}{250*250} - 0.0025)] * 250$

$\therefore \frac{Avv}{Sver}$= 0.5

Smax= Lw/3 = 6000/3 = 2000 mm

= 3h = 3*250 =750mm

$= 45cm \ll$ Controlled.

Select Ø12 :

Avv = 2 *113 = 226 mm^2

$$\frac{Avv}{s} = 0.5 \rightarrow \text{Sreq} = \frac{226}{0.5} = 452 \text{ mm}$$

∴**<u>Select Ø12 @ 150 mm at each side.</u>**

CHAPTER 5 : RESULTS AND RECOMMENDATIONS

5.1 Introduction

5.2 Results

5.3 Recommendations

Figure 5- 1 3D photo for the Hospital

5.1 INTRODUCTION

After starting the project and start dealing with problems that had been faced during the work on it, it is necessary to summarize the results that were reached and to give some recommendations that will be helpful for students who will work on such projects.

One of the most prominent problems that we faced in the project was the presence of two different levels of the basement floor slab, where one of these slabs was one way ribbed slab and the other one is one way solid slab, we solved it by making drop beams to connect between them.

5.2 RESULTS

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

1. The most important step before starting a design is to study the architectural plans carefully to distribute the columns correctly.

2. Gaining experience in using structural programs cannot be reached without an understanding of basic concepts of the structural design.

3. When choosing the structural system it is better to distribute ribs in the short direction and beams in the long one that will reduce loads that act on beams which leads to reducing of reinforcement which meant reducing costs.

5.3 RECOMMENDATIONS

After starting the project and start dealing with problems that had been faced during the work on it, some recommendations should be mentioned that may help students who will work on such projects after us.

First of all, the architectural drawings had to be prepared and studied carefully to choose the most appropriate structural system. Collecting data about the project is an important step as the study of the site and the type of soil are important in choosing the construction materials to be used. Before starting the design of the building a good structural planning must be done to determine the location of columns, beams, and shear walls to fit with architectural plans.

References

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