Palestine polytechnic university

College of engineering & technology

Department of civil engineering & architecture

Building engineering

Graduation Project

NAME OF PROJECT

Structural designs for Al-Hayat Hospital

TEAM OF WORK

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SUPERVISOR

DR. Maher Amro

2021-January

Palestine polytechnic university

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Introduction to Graduation Project

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Structural Designs for Al-Hayat Hospital

On the instructions of the professor supervising the project and with the approval of all the members of the examiner, this project is submitted to the Department of Civil engineering and architecture in the Faculty of Engineering to meet the requirements of the Department for bachelor's degree.

Project supervisor's signature | **Signature of the head of the department**

DR. Maher Amro | **DR. Faydi Shabana**

………………………... | …………………………..

2020-August

Abstract

The main objective of the project is to make a structural design for all the structural elements that the project contains, from foundations, walls, columns, beams, slabs and many other structural elements in the building.

The project consists of six floors and three floors, car garages and outdoor car parks. The floors have a variety of services with a total area of 22,375 square meters. The design from an architectural point of view is distinguished by that it was done in a modern civilized style based on containing several space blocks distributed in a symmetrically functional and aesthetic manner, as it is In the distribution of space blocks, consideration was given to providing users with convenience, speed and ease of access.

The importance of the project lies in the diversity of the structural elements in the building such as beams, columns, concrete slabs, the multiplicity of blocks and the presence of retreats in the floor space.

It is worth noting that the Jordanian code will be used to determine live loads and to determine earthquake loads. As for structural analysis and section design, the American code (ACI_318_14) will be used, and it must be noted that some computer programs such as: -
AutoCAD (2016), Atir and Microsoft Office The project will include a detailed structural study of identifying and analyzing the structural elements and the various expected loads, then the structural design of the elements and preparing the operational plans based on the prepared design of all the structural elements that make up the structural structures of the building. It is expected after the completion of the project to be able To provide the structural design for all the structural elements, God willing.

الإهـــــداء

إلى الشموع التي استطاعت قهر الظلام بقوة إرادة نورهما... الذين كلما مر الوقت أكثر

نفهم كم هو صعب أن نحاول سداد ديوننا لهم.... خاصة عندما يكون "الثبات"

على ما نؤمن به...هو من بعض غرسهم

أمهاتنا وآبائنا أدام الله نورهم..
إلى العلم، والتربية، والوقار، والإخلاص، والتواضع

أساتذتنا الكرام..

إلى دعائم قوتنا وطموحنا.... بلسم علتنا وجروحنا

إخواننا وأخواتنا.....

إلى كل الاوفياء المخلصين الذين جعلوا من الوفاء شمعة تنير دربهم

إلى من يجسدون الوفاء في أرقى صوره

اصدقائنا وصديقاتنا رفقاء الدرب..

وإلى كل من أخذ ويأخذ بأيدينا إلى قمة المجد

نهدي هذا المشروع..

<u>الشــــكــر والتــــقـــديـر</u>

ليس هناك شكرا أعظم من الاعتراف بالجميل، وليس هناك مشكور أعظم من صاحب

الفضل الذي

لا ينقطع فضله ولا تنحصر نعمه. فالحمد لله حمدا لا ينتهي عند حد ولا ينقطع عند أجل.

ووفي هذا المقام لا يسعنا إلا أن نتقدم بجزيل شكرنا، وعظيم امتناننا وتقديرنا؛ إلى كل من ساهم في انجاز مشروعنا هذا متحدين معنا كل الصعاب فلهم جميعا الشكر والتقدير كله.

ونخص بشكرنا وتقديرنا أستاذنا الفاضل الدكتور ماهر عمرو المشرف والموجه والمعلم، الذي لم يتوان ولم يتأخر عن تقديم ما أتاه الله من علم وحلم لنا.

ونشكر طاقم دائرة الهندسة المدنية والمعمارية كل بمكانه الذين كرسوا وقتهم وجهودهم لمساعدتنا ومساعدة زملائنا طوال سنوات الدارسة.

كما نتقدم بشكرنا إلى زملائنا وزميلاتنا الأعزاء الذين لولا وجودهم لما أحسسنا بمتعة المشروع، ولا حلاوة المنافسة الإيجابية.

وختام القول مسك فالشكر كل الشكر الى ابائنا وامهاتنا واخواننا الذين لهم الدور الاكبر في الوصول لما وصلنا اليه ولعلنا نوفيهم حقهم ببلوغنا رضاهم جميعا.

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- **Ac = area of concrete section resisting shear transfer**
- **As = area of non-pre-stressed tension reinforcement.**
- **$AS^{`}$ = area of non-pre-stressed 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.**
- **Cc = compression resultant of concrete section.**
- **Cs = compression resultant of compression steel.**
- **DL = dead loads.**
- **d = distance from extreme compression fiber to centroid of tension reinforcement.**
- **Ec = modulus of elasticity of concrete.**
- **$fc^{`}$ = compression strength of concrete.**
- **fy = specified yield strength of non-pre-stressed reinforcement.**
- **h = overall thickness of member.**
- **Ln = length of clear span in long direction of two- way construction, measured face-to-face of supports in slabs without beams and face to face of beam or other supports in other cases.**
- **LL = live loads.**
- **Lw = length of wall.**
- **M = bending moment.**
- **Mu = factored moment at section.**
- **Mn = nominal moment.**
- **Pn = nominal axial load.**

- **Pu = factored axial load**
- **S = Spacing of shear in direction parallel to longitudinal reinforcement.**
- **Vc = nominal shear strength provided by concrete.**
- **Vn = nominal shear stress.**
- **Vs = nominal shear strength provided by shear reinforcement.**
- **Vu = factored shear force at section.**
- **Wc = weight of concrete.**
- **W = width of beam or rib.**
- **Wu = factored load per unit area.**
- **Φ = strength reduction factor.**
- **ε_c = compression strain of concrete = 0.003.**
- **ε_s = strain of tension steel.**
- **$\acute{\varepsilon}_s$ = strain of compression steel.**
- **ρ = ratio of steel area.**

Chapter 1
Introduction of the project

- **1.1 Introduction**
- **1.2 Project overview**
- **1.3 What is the problem that facing this project?**
- **1. 4 why this project was chosen?**
- **1. 5 The purpose of this project**
- **1. 6 The purpose of this project**
- **1. 7 Scope of the project**
- **1. 8 Scope of the project**

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:

- Measure and map the earth's surface.
- Design and supervise the construction of bridges, tunnels, large buildings, dams, and coastal structures.

Plan, layout, construct, and maintain railroads, highways, and airports.
Devise systems for the control and efficient flow of traffic.
Plan and build river navigation and flood control projects.
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.

Civil engineers are trained in the interactions among structures, the earth, and water, with applications ranging from highways to dams and water reservoirs. Deeply involved with specifying appropriate construction materials, many civil engineers and others are also employed by the manufacturers of those materials. Since constructing a large building or public-works project can involve elaborate planning, civil engineers can be outstanding project managers. They sometimes oversee thousands of workers and develop advanced computerization and planning policies. Most significantly, many civil engineers are involved with preserving, protecting, or restoring the environment.

1.2 Project overview

We chose one of the hospitals in Yatta , a hospital that specializes in treating cancerous tumors, 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. The project consists of five floors after the ground floor and three floors for car parks with a total area (22375 m 2).

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 "electrical and mechanical engineering and construction" so that users find the feeling of being comfortable in the place.

1.3 What is the problem that facing this project?

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.

1. 4 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 - 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.

2- Because this project is widely implemented 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 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.

4- The group that worked on the project needs to be constructive, so that it is similar to the projects carried out at work outside the university

1. 5 The purpose of this project

1- Making structural designs for the various structural elements in the project.

2- Training on how to apply between the construction and architectural functions of the building.

3- Linking the relationship between the theoretical aspects that we have gained at the university practical aspects that we have learned in the labor market through courses in the field training.

4- the skills of using the computer in the process of structural design to raise the efficiency and qualifications of the civil engineer before moving to work.

5- Linking information and applying the equations that have been studied in different courses.

6- Know and use the appropriate code.

7- Know the loads to which the building and the effect of loads on it.

8- Preparation of complete structural plans detailed so that any structural engineer can understand these plans.

1. 6 The purpose of this project

1- Work of full and detailed study of all architectural plans "general site, plans, elevations, sections".

2- Study of the distribution of structural elements in the building.

3 - Structural study of the building that determined.

4- Structural analysis of some structural elements.

5- Structural design of the selected structural elements.

6- Prepare and draw the structural plans for the design elements.

7 - Writing and finalizing the project.

1. 7 Scope of the project

Our study in this project is limited to studies and analysis and designs of structure, where we must do designs for selected and specific elements, such as: ribs and concrete slabs, beams, columns, foundations, and the design of stairs “ flight and landing “ , as well as the work of integrated structural plans in all its details for those

elements, especially studies Constructive, as well as make the necessary architectural modifications, if any, on the architectural design in the event of the possible structural solutions to ensure an integrated project of both architectural and structural aspects.

1. 8 Scope of the project

It is summarized in five chapters as follows:

- Chapter One:

Includes an introduction to the project containing the problem of the project, the reasons for the selection of the project, its objectives, and the steps followed for the work of the project.

- Chapter Two:

It includes the architectural description of this project; in terms of the general location, the area plan, the description of the facades and sectors from the architectural point of view and the description of the movement inside the building.

3 - Chapter Three:

This chapter describes the structural description of the project elements.

- Chapter Four:

Contains analysis and design processes for the various structural elements of the project.

- Chapter Five:

This chapter represents the end point with its results and recommendations, which are the product of the work that has been done.

Chapter 2
Architectural description

- **2.1 Introduction of architecture description for the project**
- **2.2 About this project**
- **2.3 Location of the Project**
- **2.4 The purpose of choose the location of project**
- **2.5 Floors Description**
- **2.6 Movement Description**
- **2.7 Elevations Description**
- **2.8 Sections Description**

2.1 Introduction of architecture description for the project

Architecture is the mother of engineering science, and it is not the birth of this time, but is since the creation of the human who unleashed his talents and thoughts, so move these talents from the life of the caves to the best form of luxury.

The shape of the buildings differs at all times from different eras and there are several forms of this building that distinguish it from the rest of the patterns.

The design process for any structure or building is carried out through several stages until it is fully completed.

First, the architectural design phase will be determined. In this stage, the shape of the structure will be determined and the various functions and requirements for which the building will be constructed are taken; Lighting, ventilation, movement, mobility and other functional requirements.

After completing the architectural design process, the structural design process begins, which aims to choose the structural system that is appropriate to the building's function and is consistent with its architectural design, and as this process aims to define the dimensions of the structural elements and arm them, in order to resist the various loads that are exposed to these elements that in turn By transferring loads to the foundations that completely transfer the loads to the soil.

2.2 About this project

The idea of the project is based on the structural design of a hospital for cancerous tumors, taking into account all model architectural standards, through the use The modern architectural character, which includes the different building elements, and takes into consideration all the good and psychological comfort in terms of space, ease of movement, public safety requirements and other things, in addition to taking into account the possibility of construction in the future.

2.3 Location of the Project

The design process of any project depends mainly on the study of the site on which the building will be constructed very carefully whether it relates to the geographical location or the expected climatic impacts in the region, so give a general idea of the elements of the site, from clarifying the land on which the building will be built and the relationship of the site to the streets and services Surrounding, the height of the surrounding buildings and the direction of the prevailing wind and the path of the sun.

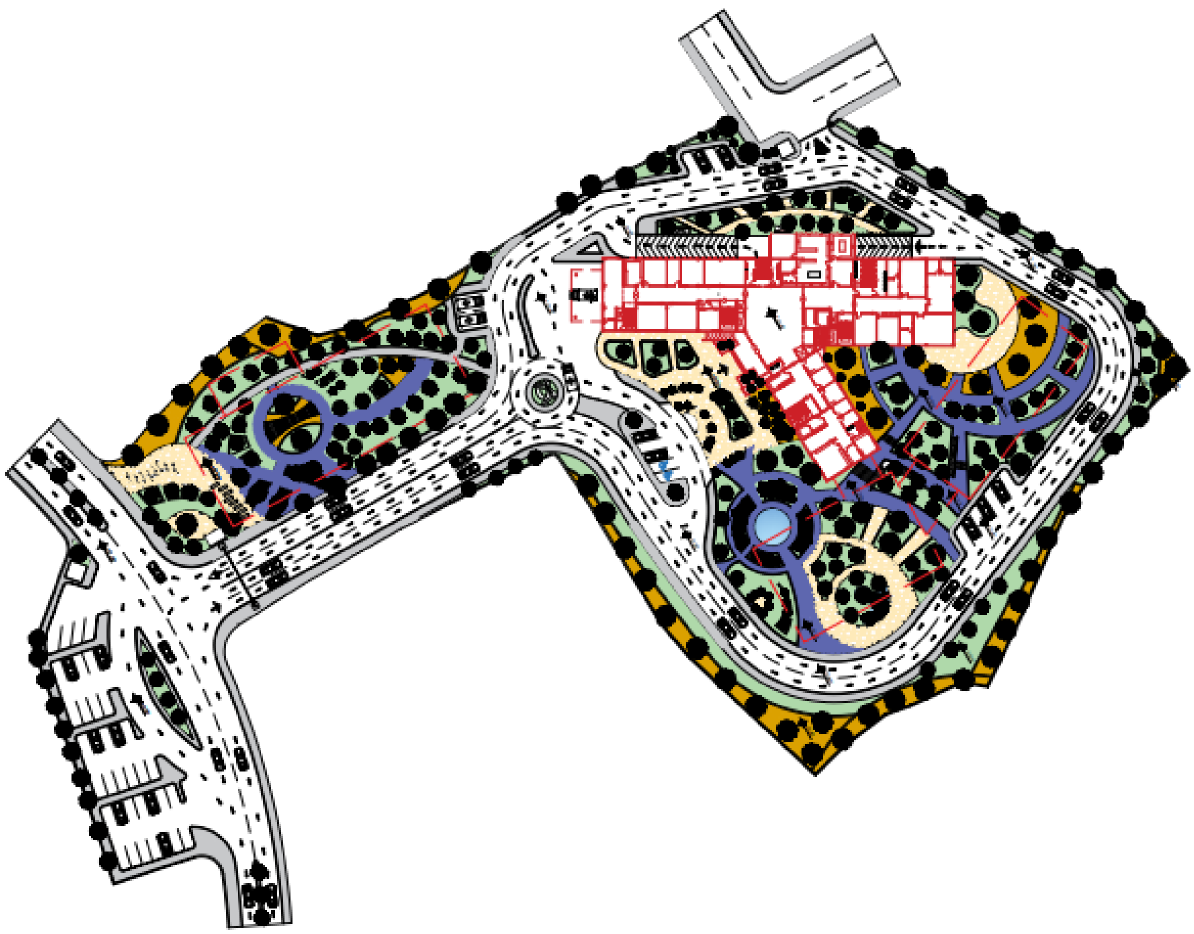
2.4 The purpose of choose the location of project

The purpose of choosing this site for the project depends on satisfactory reasons, including the city's need to build this hospital on this site.

The size of the land is compatible to accommodate this project, and this land site reaches most of the various services of the water and sewage network and that land is located on the main street.

2.5 Floors Description

A. Site Plane:



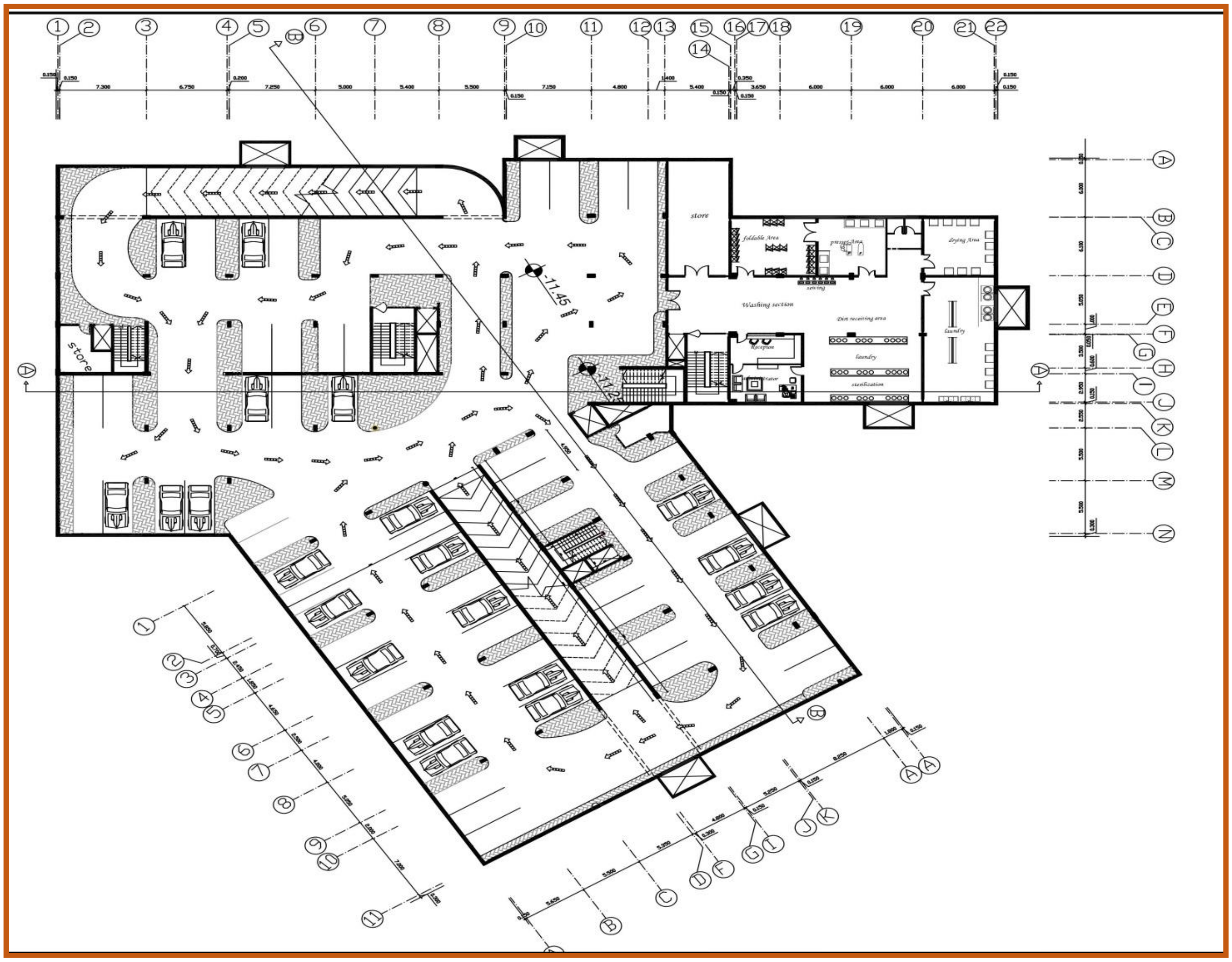
Picture 1: site plane

B. (basement 3):

It consists of two parts, and there are ventilation holes around the building and reach the ground floor and its area is 3631 m^2.

• The first section: Garage.

• The second section: the chemical radiation department: It is not cut off because there is no such section in our country, the dimensions of the devices used.



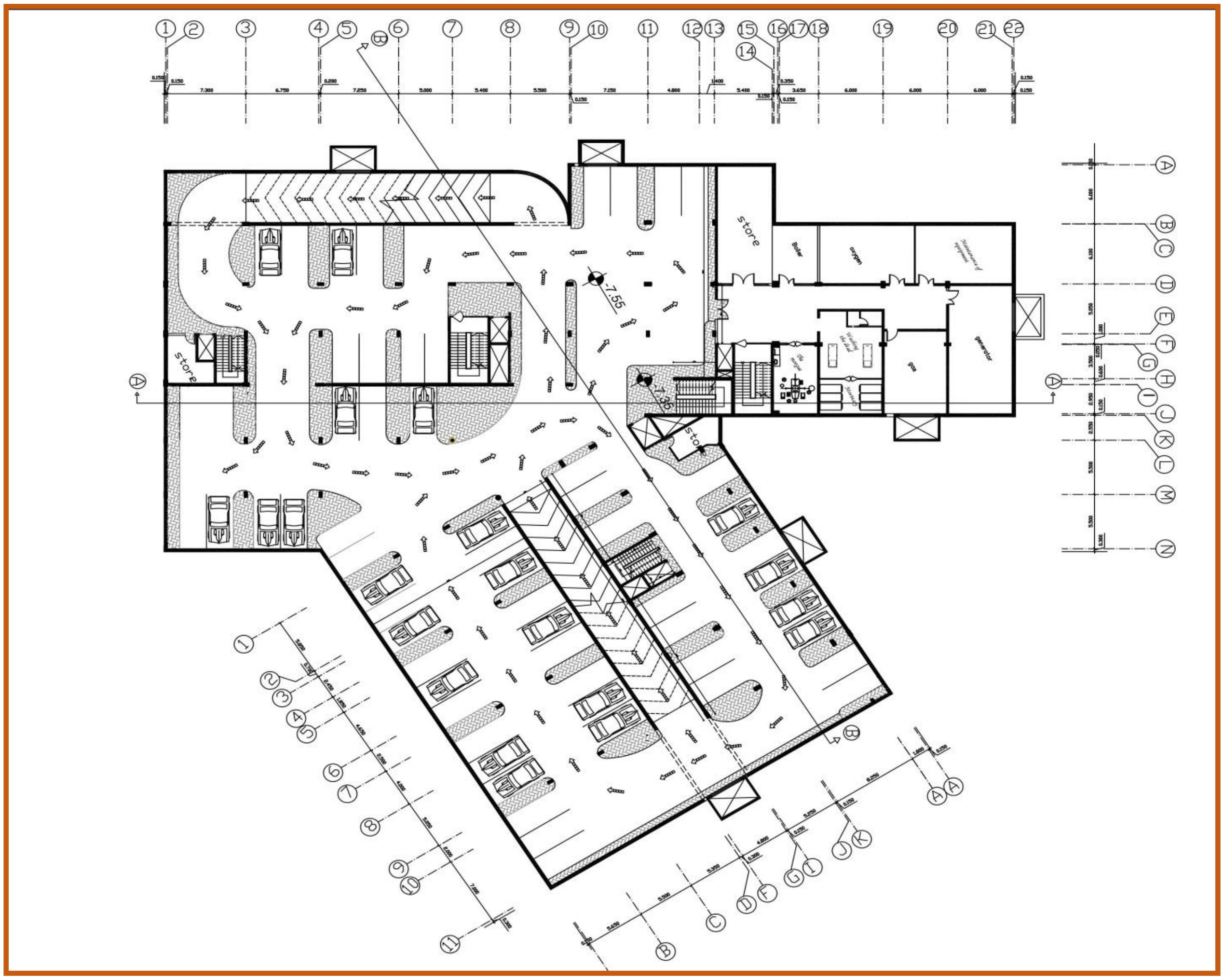
Picture 2: basement 3

C. (Basement 2)

It consists of two parts. There are skylights for ventilation around the building that reach the ground floor and its area is 3631 m^2.

• The first section: Garage.

• The second section: A department inside which contains more than one room such as (the storehouse, boiler, oxygen, maintenance, gas storage, a room inside which there are refrigerators of the dead, the place of their washing, the dissection room.

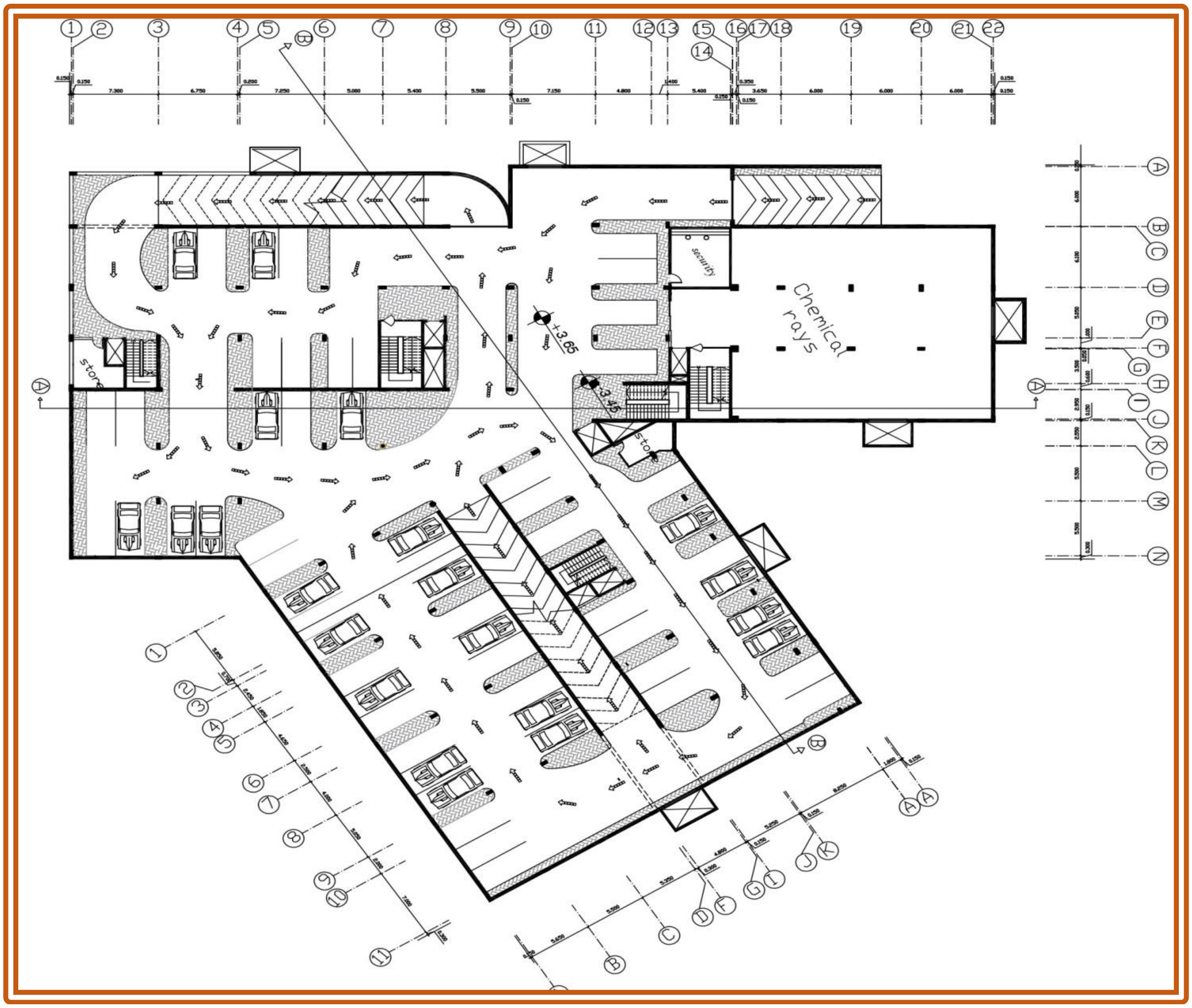


Picture3: basement 2

D. (basement 1)

It consists of three sections, and there are skylights for ventilation around the building and reach the ground floor and its area is 3631 m^2.

- The first section: Garage.
- The second section: The washing department: in which clothes and furnishings are washed in rooms and nurses.
- The third section: It is a storehouse for other services

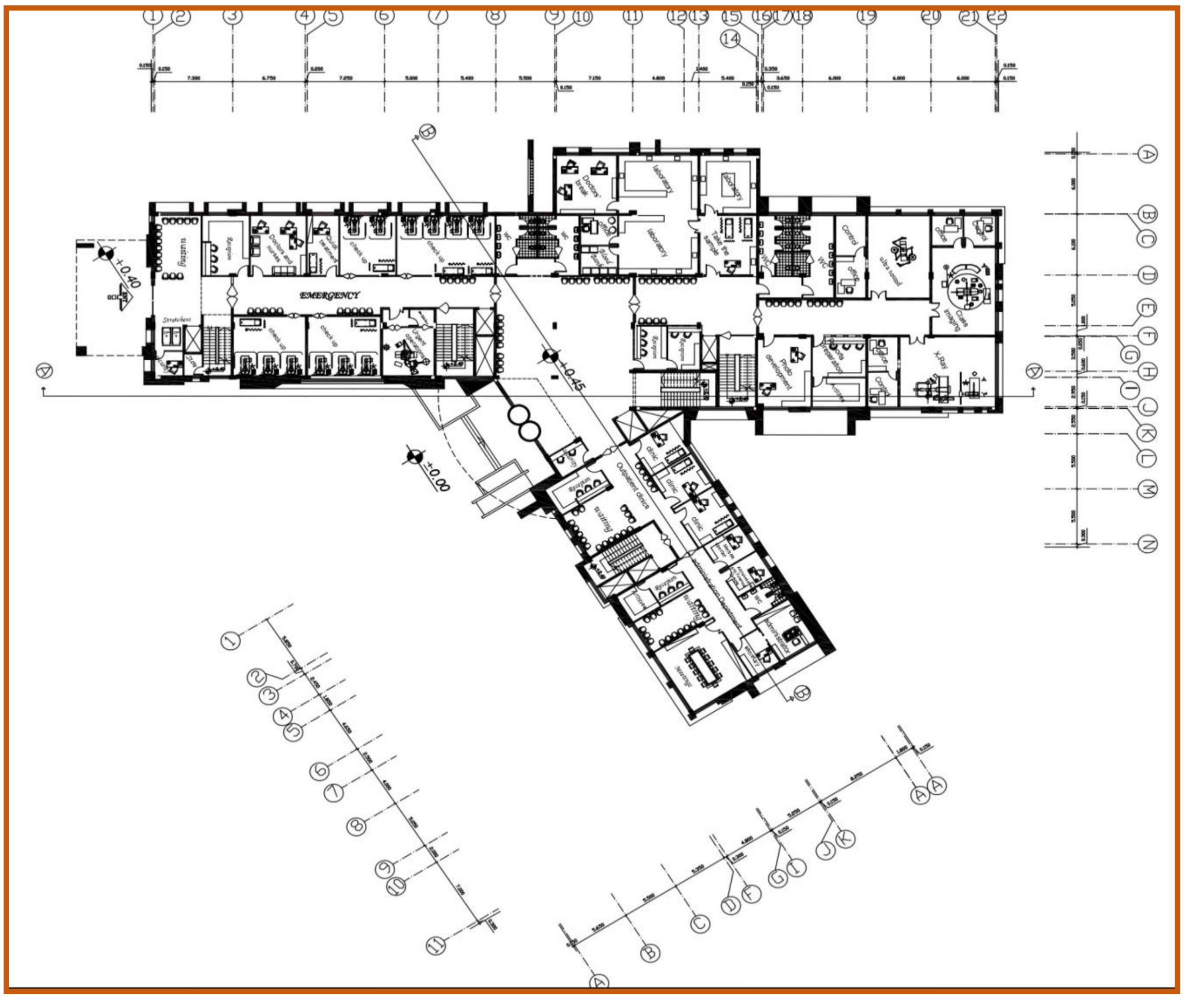


Picture4: basement 1

E. (Ground Floor G.F)

it consists of three sections for services and bathrooms and its area is 2192 m^2.

- The first section: the emergency department, which has its own entrance, which is located on the northeastern side of the building, and this entrance is a secondary entrance
- The second section: the outpatient clinics section at the western entrance. The third section: The laboratory and radiography department, in which the department is located, which is located in the main places in the southern side.

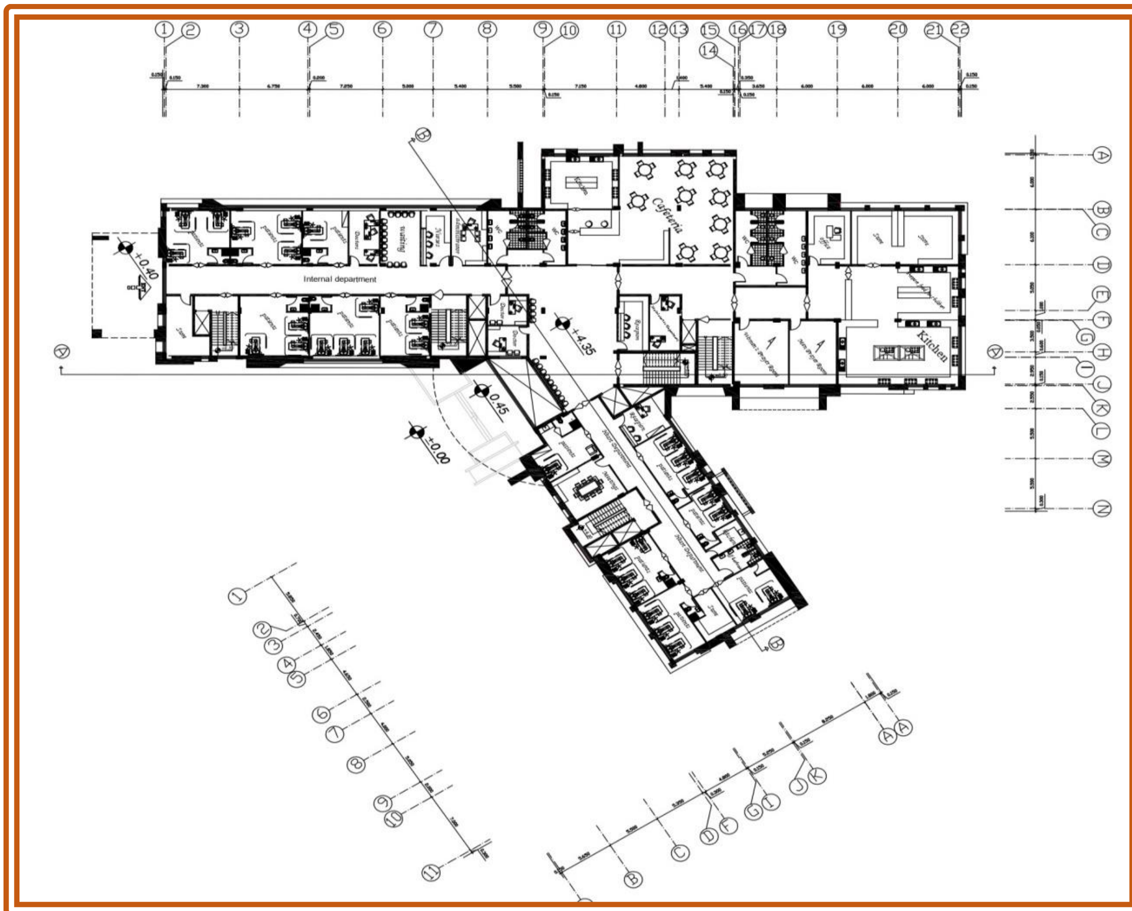


Picture5: Ground Floor G.F

F. (first Floor)

it consists of three sections in addition to service rooms and bathrooms and its area is 2192 m^2.

- The first section: the internal section, which is located on the northeastern side of the building.
- The second section: the heart section, located on the northwestern side of the building.
- The third section: The hospital's home kitchen section, which is fully equipped and has a cafeteria beside it. There are two rooms for the chapel, which is located in this section entirely in the south side of the building.

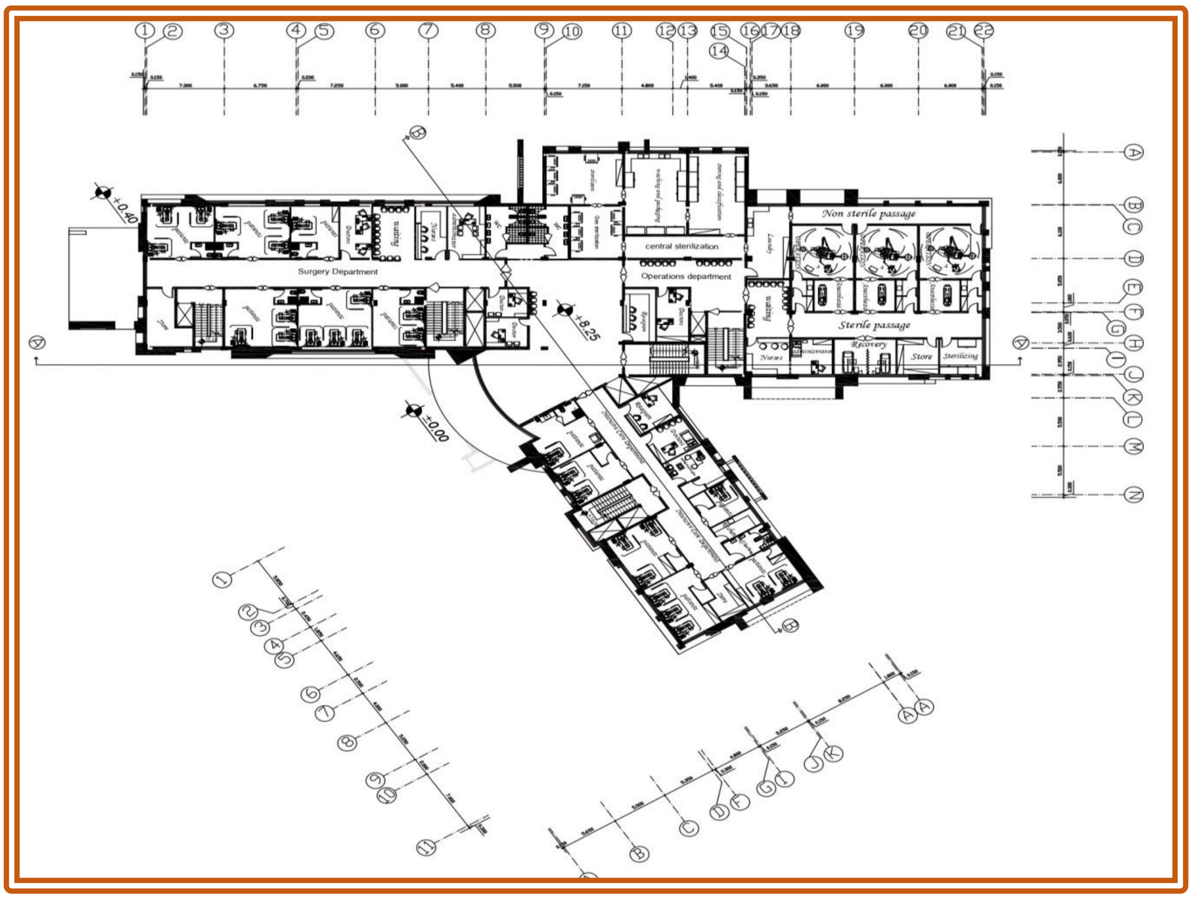


Picture6: First Floor

G. (Second Floor)

it consists of four sections in addition to service rooms and bathrooms and its area is 2192 m^2.

- The first section: The surgical department, which is located on the northeastern side of the building.
- The second section: the intensive care section located on the northwestern side of the building.
- The third section: The Operations Department, which contains three rooms equipped for operations, which is located in the southern side of the building.

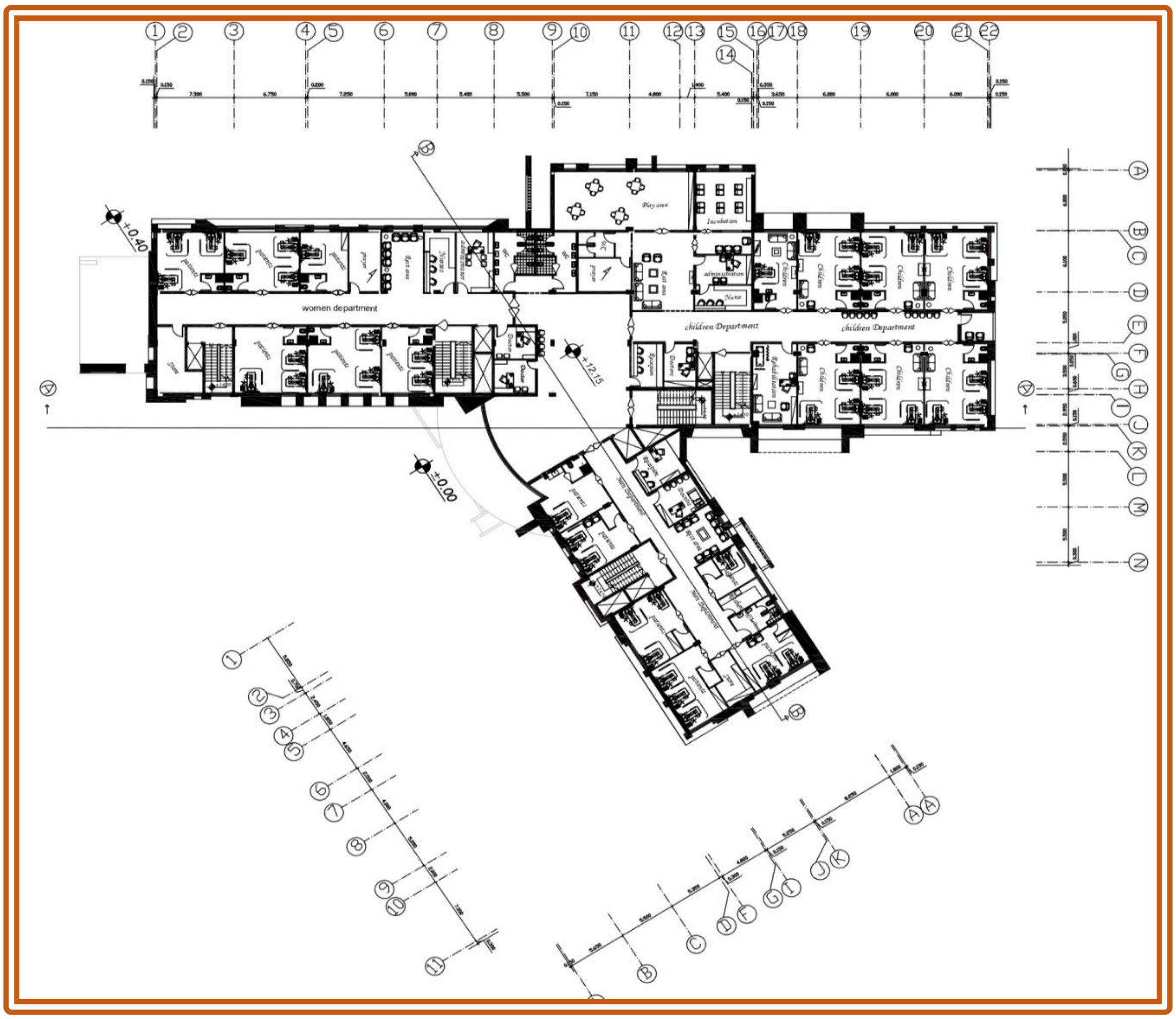


Picture7: second Floor

H. (third and fourth Floor)

each floor consists of three sections in addition to service rooms and bathrooms and its area is 2192 m^2.

- The first section: the women's section, which is located on the northeastern side of the building.
- The second section: the men's section, which is located on the northwestern side of the building.
- The third section: the children's section. This section is located in the south side of the building.



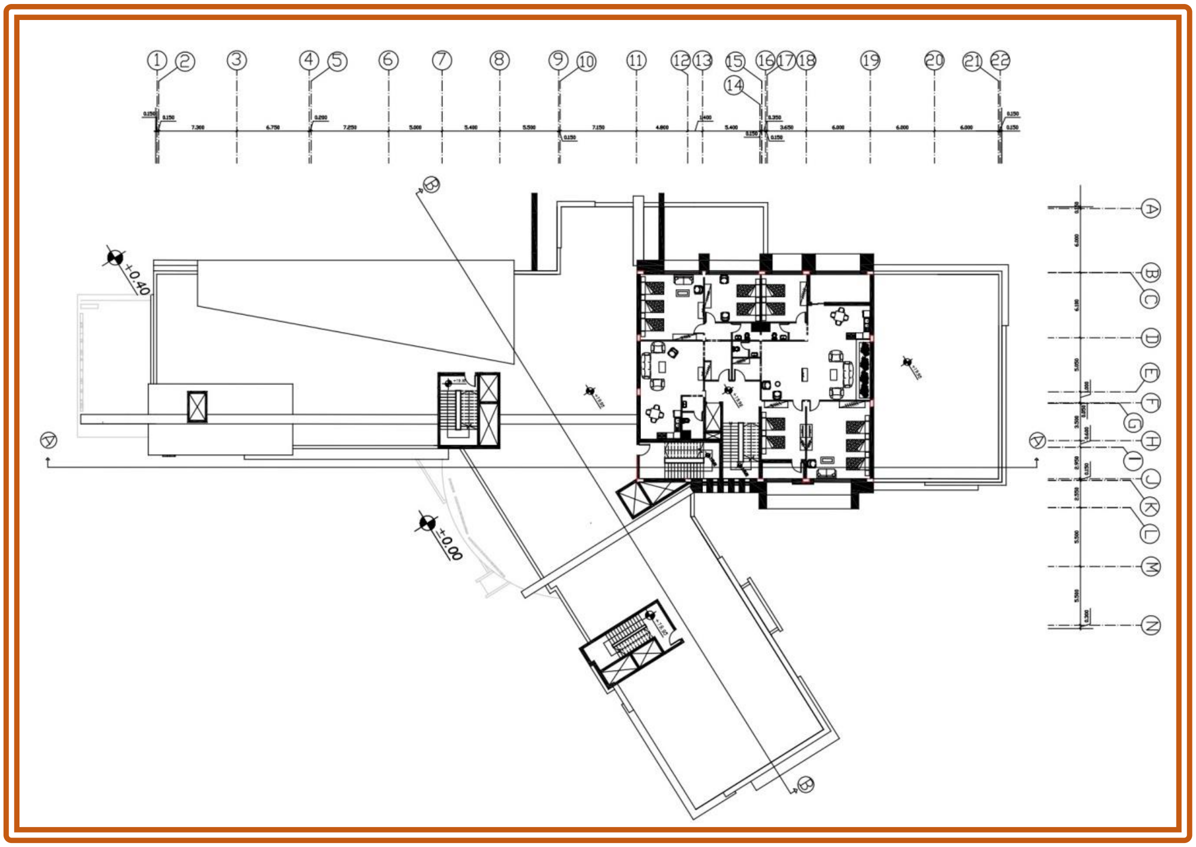
Picture8: third and fourth Floor

I. 8-(fifth floor)

It consists of two special sections for doctors, in addition to service rooms and bathrooms and its area is 522 m^2.

• The first section: the women's section.

• The second section: the men's section



Picture9: fifth Floor

2.6 Movement Description

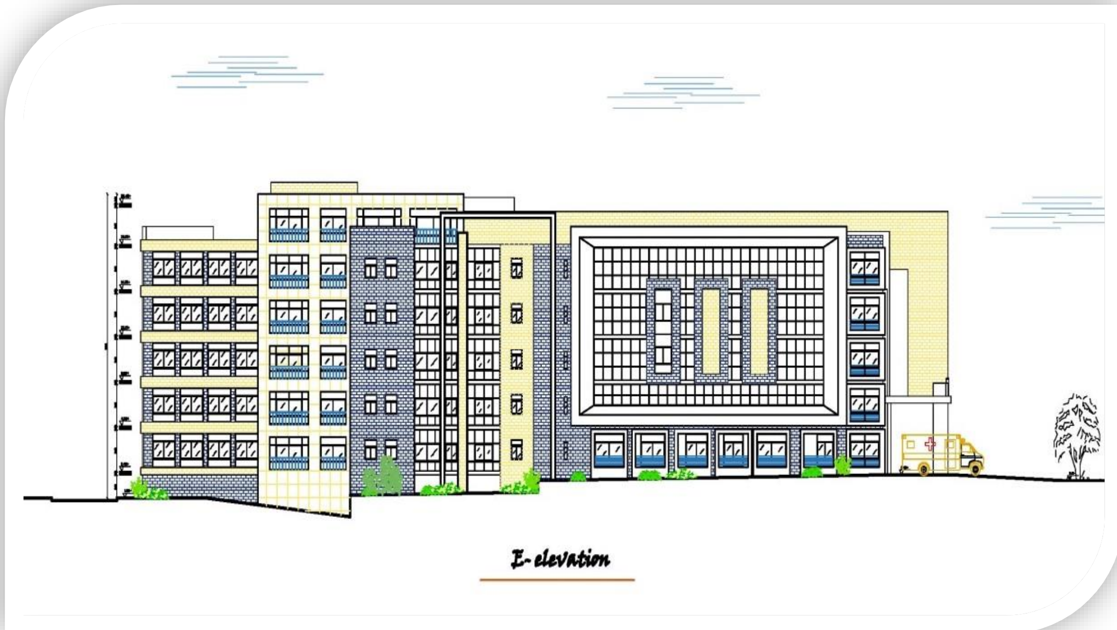
Movement and the process of movement between parts of the building is clear and easy, and is intended to move between rooms and other facilities easily and from within the building to the outside as well, which in turn allows freedom of entry and exit from the building where the movement within the building is divided into two types: horizontal movement within the building and vertical movement Between the floors of the building, which are by stairs, escalators and elevators.

2.7 Elevations Description

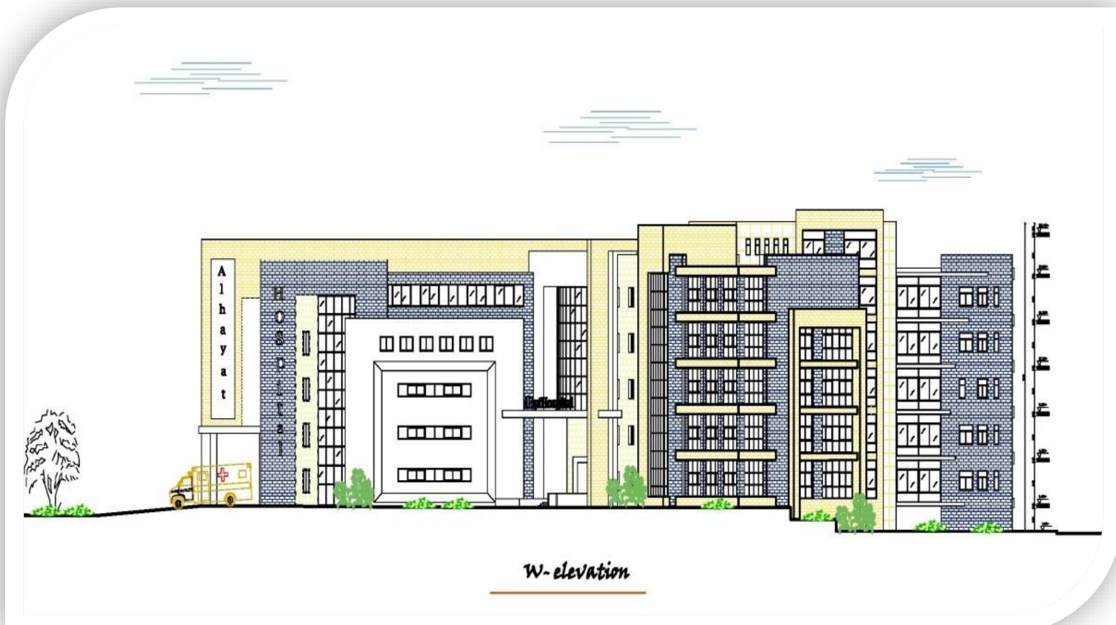
The four facades of the building are not adjacent to any adjacent buildings, which helped in providing natural lighting and optimal ventilation of the building and the consist of windows in the Elevations of the building that get better in lighting and ventilation of the building, in addition to taking into account the presence of On the ventilation element of the building such as plaque and highlight the architectural beauty element.

Picture10: North Elevation

Picture11: South Elevation

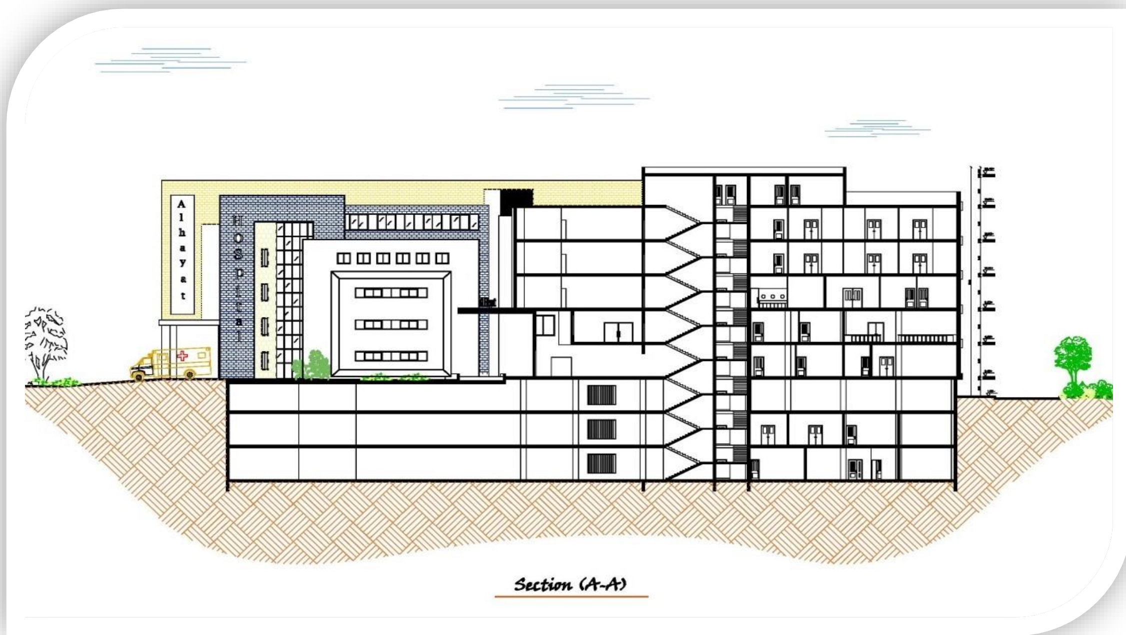


Picture12: East Elevation

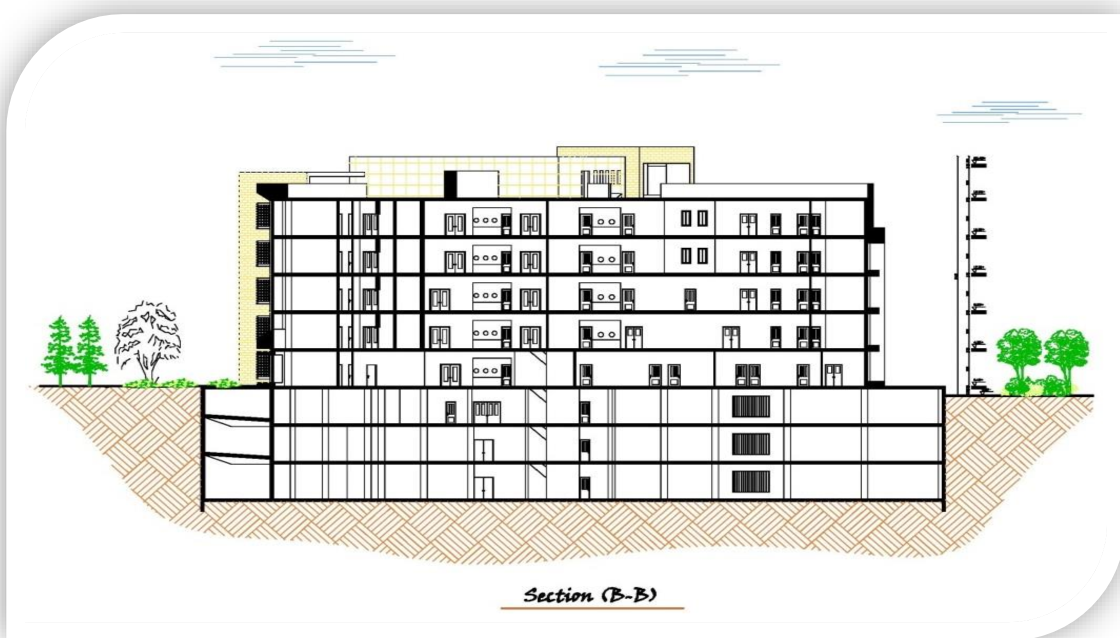


Picture13: West Elevation

2.8 Sections Description



Picture14: section (A-A)



Picture15: section (B-B)

Chapter 3
Structural description

- **3.1 Introduction of Structural description for the project**
- **3.2 Purpose of Structural Design**
- **3.3 The Loads**
- **3.4 Description of Structural Elements**
- **3.5 Expansion joints**

3.1 Introduction of Structural description for the project

After the completion of the architectural description in the second chapter is not to move to one of the most important stages that pass during the implementation of any of the construction projects, namely the stage of structural design.

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

3.2 Purpose of Structural Design

Structural design work aims to choose a safe construction system that keeps the building as long as possible while remaining fit for the purpose for which it was found, and able to withstand the forces located on it, so that the structure meets the requirements and desires of users, and thus the construction elements are determined based on the following:

- Factor of safety: We can do it through choose a section of structural elements able to withstand the forces and stresses resulting.

- Economic cost (Economy): is achieved by selecting the appropriate building materials and by choosing the ideal low-cost section.

3.3 The Loads

Types of loads acting on a structure are:

1 - Dead loads

2 - Live loads

3 - Wind loads

4 - Snow loads

5 - Earthquake loads

3 – 3 – 1 Dead Loads

The first vertical load that is considered is dead load. Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self-weight of structural members, permanent partition walls, fixed permanent equipment’s and weight of different materials. It majorly consists of the weight of roofs, beams, walls and column etc. which are otherwise the permanent parts of the building.

The calculation of dead loads of each structure are calculated by the volume of each section and multiplied with the unit weight. Unit weights of some of the common materials are presented in table below.

No.	Material	Density (KN / m^3)
1	Mortar	22
2	Tiles	23
3	R. Concrete	25
4	Hollow Block	10
5	Plaster	22
6	Sand	17

Table1: Density of material

3 – 3 – 2 Live Loads

The second vertical load that is considered in design of a structure is live loads.

Live loads are either movable or moving loads without any acceleration or impact. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc.

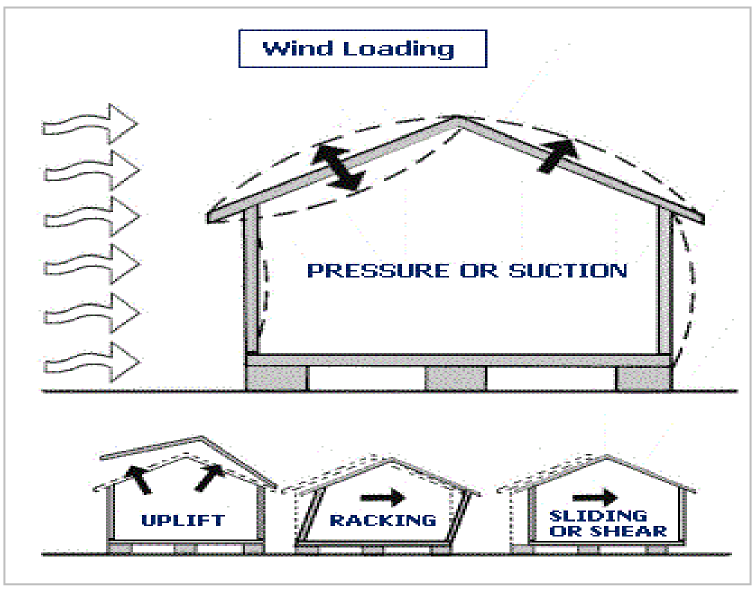
No.	Using for	Live load (KN/m^2)
1	Operations rooms	3
2	The Wings	2
3	Private rooms	2

Table2: Live load of Jordanian code

3 – 3 – 3   Wind Loads

Wind load is primarily horizontal load caused by the movement of air relative to earth. Wind load is required to be considered in structural design especially when the heath of the building exceeds two times the dimensions transverse to the exposed wind surface.

For low rise building say up to four to five stories, the wind load is not critical because the moment of resistance provided by the continuity of floor system to column connection and walls provided between columns are sufficient to accommodate the effect of these forces. Further in limit state method the factor for design load is reduced to 1.2 (DL+LL+WL) when wind is considered as against the factor of 1.5(DL+LL) when wind is not considered.



Picture16: Wind load

3 – 3 – 4 Snow Loads

Snow loads constitute the vertical loads in the building. But these types of loads are considered only in snowfall places.

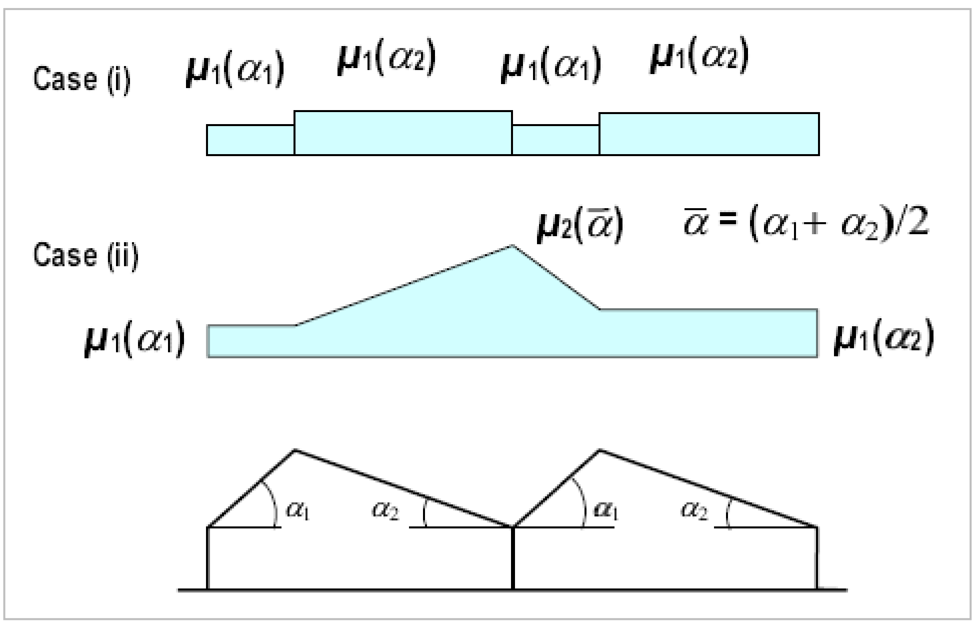
The minimum snow load on a roof area or any other area above ground which is subjected to snow accumulation is obtained by the expression:

$$S = \mu \alpha_0$$

W S = Design snow load on plan area of the

μ = Shape coefficient= Shape

α_0 = Ground snow



Picture17: Snow load

3– 3 – 5 Earthquakes Loads

Earthquake forces constitute both vertical and horizontal forces on the building. The total vibration caused by an earthquake may be resolved into three mutually perpendicular directions, usually taken as vertical and two horizontal directions.

The movement in the vertical direction does not cause forces in the superstructure to any significant extent. But the horizontal movement of the building at the time of earthquake is to be considered while designing.

The response of the structure to the ground vibration is a function of the nature of foundation soil, size and mode of construction and the duration and intensity of ground motion.

The seismic accelerations for the design may be arrived at from the seismic coefficient, which is defined as the ratio of acceleration due to earthquake and acceleration due to gravity. For monolithic reinforced concrete structures located in the seismic zone 2, and 3 without more than 5 stories high and importance factor ‘’ R ‘’ less than 1, the seismic forces are not critical

3.4 Description of Structural Elements

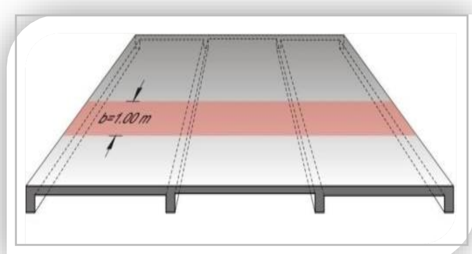
3– 4 – 1: Slabs

Slabs are constructed to provide flat surfaces, usually horizontal in building floors, roofs, bridges, and other types of structures. The slab may be supported by walls or by reinforced concrete beams usually cast monolithically with the slab or by structural steel beams or by columns, or by the ground. Slabs are classified into more than 16 types; we will show the top 6 that using in our country.

Types of Slabs

1 – One-way Solid Slabs

One-way slab is a slab which is supported by beams on the two opposite sides to carry the load along one direction.



Picture18: section to One-way Solid Slabs

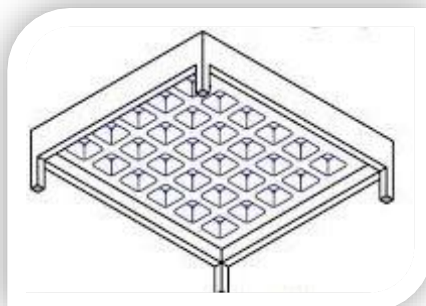
The ratio of longer span (l) to shorter span (b) is equal or greater than 2, considered as one-way slab because this slab will bend in one direction i.e., in the direction along its shorter span.

$$2 \leq \frac{long\ Span}{Short\ Span}$$

2 – Two-way Solid Slabs

Two-way slabs are a slab supported by beams on all the four sides and the loads are carried by the supports along both directions, it is known as two-way slab. In two way slab, the ratio of longer span (l) to shorter span (b) is less than 2.

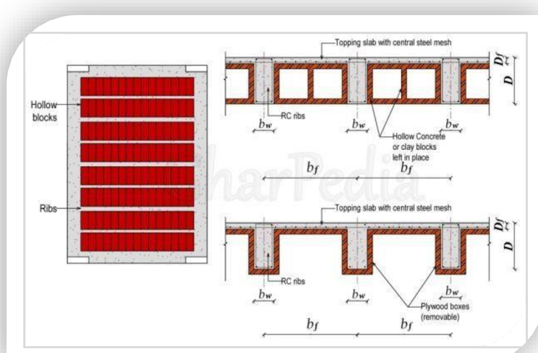
$$2 > \frac{long\ Span}{Short\ Span}$$



Picture19: section to two-way Solid Slabs

3 – One-way Ribbed Slabs

A one-way ribbed slab consists of a series of small, reinforced concrete T beams that are connected with girders that in turn carried by the building column. T beams are known as joists which are formed by setting steel pan at a constant spacing.

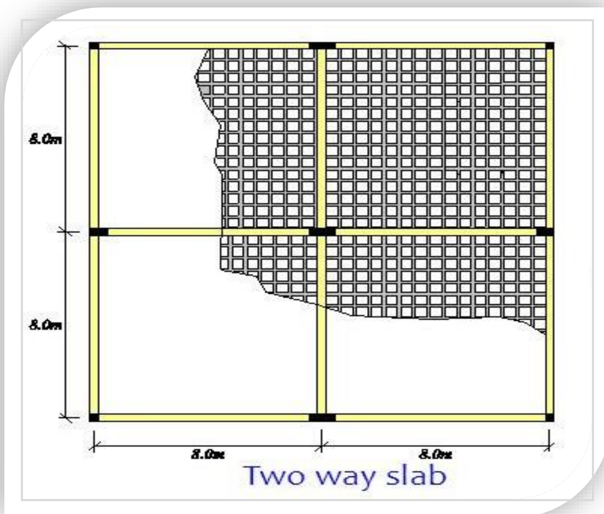


Picture 20: section to one-way ribbed Slabs

- Concrete is cast between those spacing to make those ribs and, in this way, the slab also cast and the slab becomes the flange of T beam.

4-Two-way Ribbed Slabs

It's like one-way ribbed slabs, but the ribs here in two directions, because the ratio between long span and too short span is less than 2

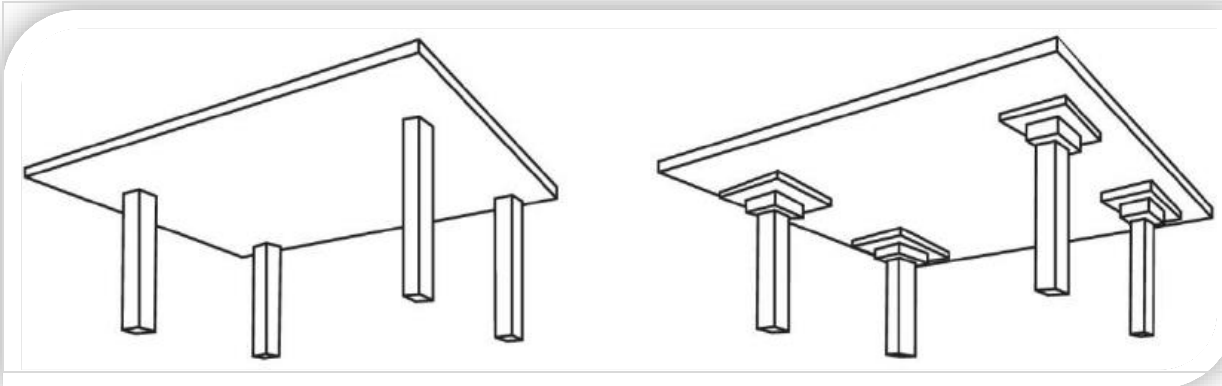


Picture 21: section to two-way ribbed Slabs

5– Flat Slabs

The flat slab is a reinforced concrete slab supported directly by concrete columns or caps.

Flat slab doesn't have beams so it is also called a beam-less slab, they are supported by columns itself, Loads are directly transferred to columns in this type construction, a plain ceiling is obtained thus giving an attractive appearance from an architectural point of view. The plain ceiling diffuses the light better and is considered vulnerable in the case of fire than the traditional beam slab construction. The flat slab is easier to construct and requires less formwork. This is one of the types of concrete slabs.



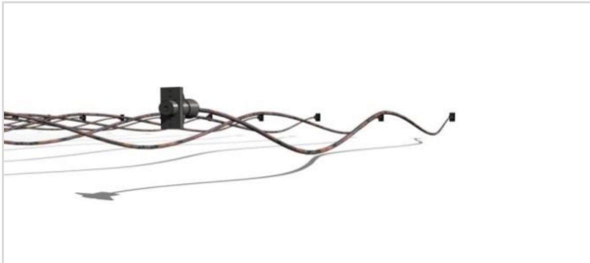
Picture 22: section to flat Slabs

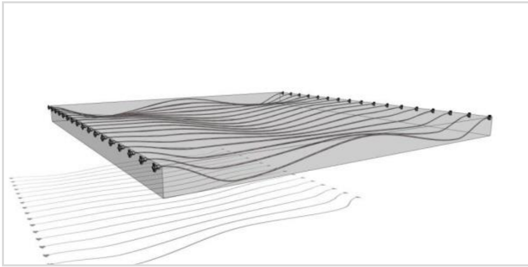
6 – Post Tension Slabs

The slab which is tensioned after constructing the slab is called' Post tension slab''. Reinforcement is provided to resist the compression. In Post tension slab the reinforcement is replaced with cables/ steel tendons.

Post-Tensioning provides a means to overcome the natural weakness of concrete in tension and to make better use of its strength in compression. The principle is easily observed when holding together several books by pressing them laterally.

In concrete structures, this is achieved by placing high-tensile steel tendons/cables in the element before casting. When concrete reaches the desired strength, the tendons are pulled by special hydraulic jacks and held in tension using specially designed anchorages fixed at each end of the tendon. This provides compression at the edge of the structural member that increases the strength of the concrete for resisting tension stresses. If tendons are appropriately curved to a certain profile, they will exert in addition to compression at the perimeter, a beneficial upward set of forces (load balancing forces) that will counteract applied loads, relieving the structure from a portion of gravity effects. This is one of the types of concrete slabs.





Picture 23: section to post tension Slabs

3 – 4 – 2: Beams

Different types of beams are used in construction of building and structures. These are a horizontal structural element that withstands vertical loads, shear forces and bending moments. Beams transfer loads imposed along their length to their endpoints to walls, columns, foundations, etc.

Types of beams:

1 - Simply Supported Beam

It is one of the simplest structural elements that both ends rest on supports but is free to rotate. It contains pinned support at one end and a roller support at the other end. On the basis of assign load, it sustains shearing and bending.

Picture 24: simply supported beam

2- Fixed Beam

It is supported at both ends and fixed to resist rotation. It is also called a built-in beam. The fixed ends produce fixing moments other than the reactions.

Picture 25: fixed beam

3- Cantilever Beam

If a beam is fixed at one end and set to be free in the end, it is termed as a cantilever beam. The beam distributes the load back to the support where it is forced against a moment and shear stress. Cantilever beams allow the creation of a bay window, balconies, and some bridges.

Picture 26: cantilever beam

4- Continuous Beam

A continuous beam has more than two supports distributed along its entire length.

Picture 27: continuous beam

5- Reinforced Concrete Beam

It is constructed from concrete and reinforcement as shown

Picture 28: Reinforced concrete beam

6- Steel Beam

It is constructed from steels and used in several applications.

Picture 29: steel beam

3 – 4 – 3: Columns

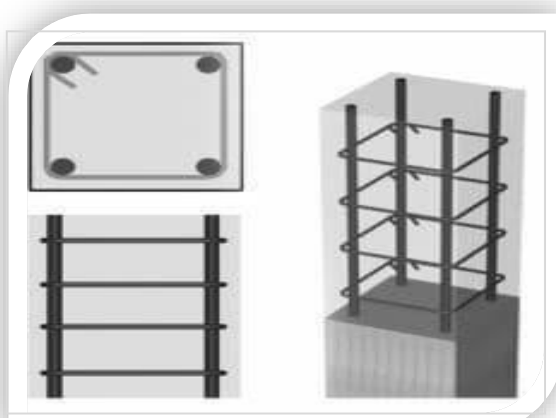
The column is a vertical structural member that carries loads mainly in compression. It might transfer loads from a ceiling, floor slab, roof slab, or from a beam, to a floor or foundations.

Types of Columns

1- Tied Column

This type of column is commonly construction from reinforced concrete. Longitudinal reinforcement is confined within closely spaced tie reinforcement.

It is estimated that 95% of all columns in buildings are tied.

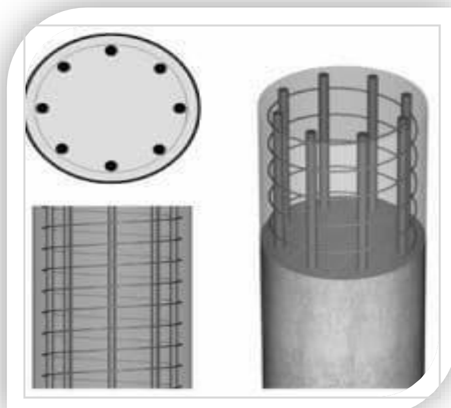


Picture 30: tied column

2- Spiral Column

The spiral column is also constructed from reinforced concrete. In this type of column, longitudinal bars are confined within closely spaced and continuously wound spiral reinforcement.

Spiral reinforcement provides lateral restrains (Poisson's effect) and delays axial load failure (ductile).



Picture 31: spiral column

3- Composite Column

When the longitudinal reinforcement is in the form of a structural steel section or pipe with or without longitudinal bars, it is called a composite column.

This type of column has high strength with fairly small cross-section, also, to exhibit good fire performance.

Picture 32: composite column

3 – 4 – 4: Walls

There are many types of walls in a building, some of that using to bearing loads on it " bearing walls", and others using to resist the overturning it's called "retaining walls", and others to resist the horizontal force like wind loads and earthquake loads called "Shear Walls ".

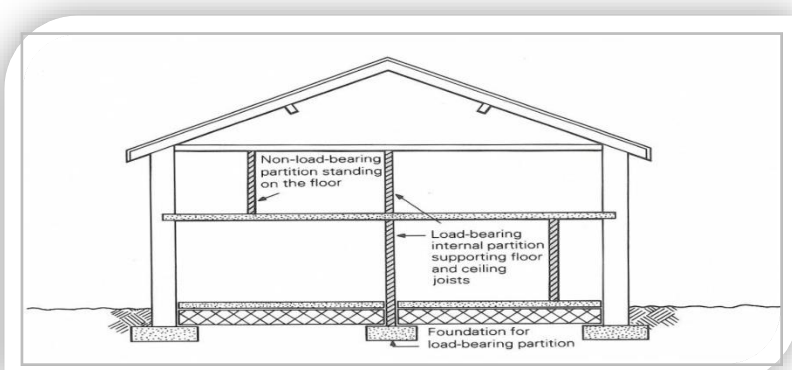
Type of Walls

Bearing Walls

Bearing walls help support the weight of the whole structure.
Any wall that sits on a foundation is a load-bearing wall, as are many walls in the center of the structure and all exterior walls. Some load-bearing walls also have posts or columns at the bottom to help support all of the weight they're carrying.

Load-bearing walls are typically right on top of each other, so if there's one on the second floor there's likely one on the first floor right underneath it. This is because load-bearing walls help move the weight down the building and must be on top of each other to do this effectively.

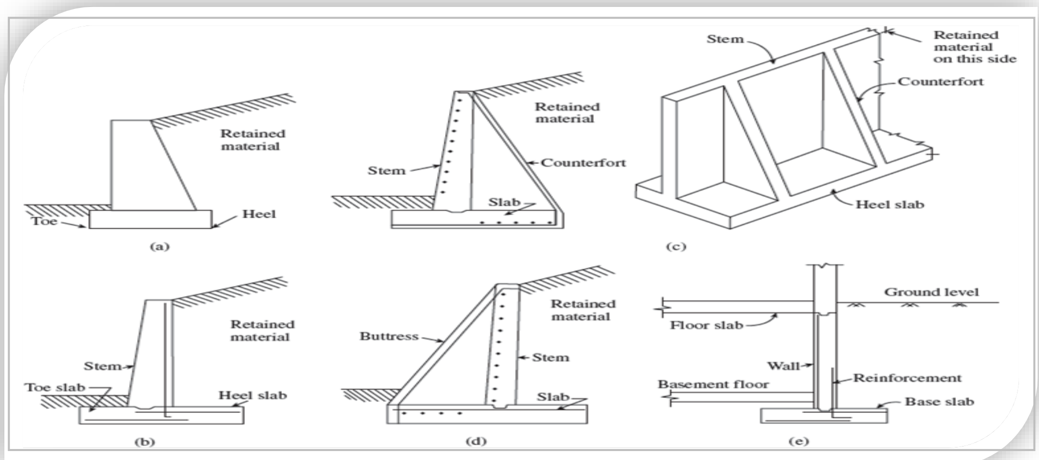
It is possible to remove a load-bearing wall without damaging the structure by replacing it with either another wall or a beam that can also support the building's weight, such as a load-bearing column.



Picture 33: Bearing walls

2-Retaining Walls

The retaining wall is a structure that is designed and constructed to withstand lateral pressure of soil or hold back soil materials. The lateral pressure could be also due to earth filling, liquid pressure, sand, and other granular materials behind the retaining wall structure. There are various types of retaining wall structures which are used for satisfying some of the goals.

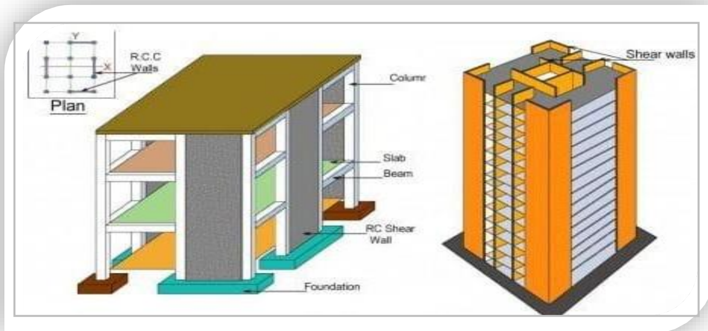


Picture 34: Retaining walls

Shear Walls

Shear wall is a structural member in a reinforced concrete framed structure to resist lateral forces such as wind forces. Shear walls are generally used in high- rise buildings subject to lateral wind and seismic forces,

Example of Shear Walls that using in our Project, Shear Walls in Elevator case and Staircase.



Picture 35: shear walls

3 – 4 – 5: Foundations

A foundation is the part of a building that fixes it into the soil. These structures provide support for the main structures that appear above the soil level, much like the roots of a tree support the stem.

One of its functions is to transfer loads from the structure to the ground. For example, slabs transfer their weight to girders, which in turn transfer that load as well as loads applied to them to the beams. Beams transfer that load and any additional loads applied to them to the columns, and finally, columns transfer that load to the foundations.

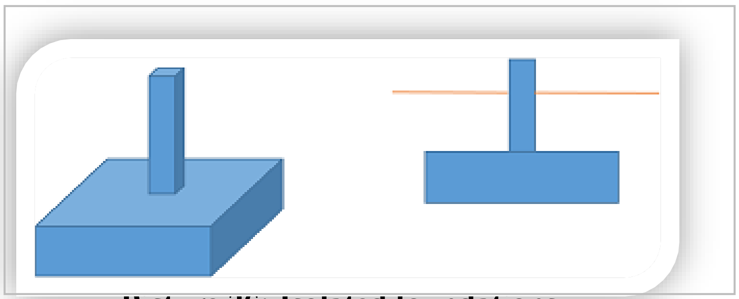
One of the duties of civil engineers is to consider the bearing capacity of the soil, and design these foundations to resist shear stress, overturning, and sliding.

Types of Foundations

Isolated Foundations

Isolated foundation can either support one column or multiple columns. This type of foundation is shallow, usually reaching no more than three meters deep.

Spread footings are used when there is a small load and the top soil layers are not weak. For example, flag poles or single-story buildings can be supported by a spread footing.



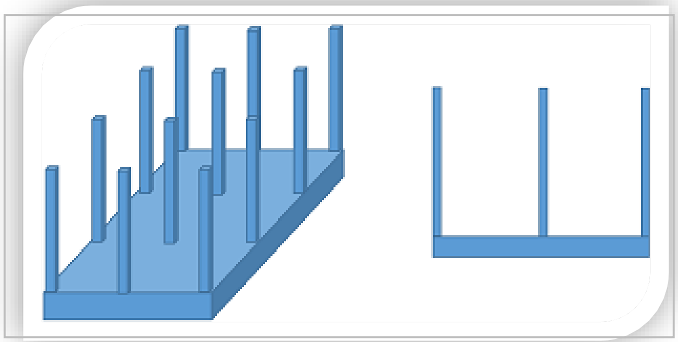
Picture 36: Isolated foundations

To construct these types of footings, the required depth is excavated, reinforcing steel bars are placed according to design, a framework is placed according to design dimensions, and concrete is poured. After the concrete reaches its maximum compressive strength, the excavation is filled with soil, and the soil is compacted.

MAT Foundations

Mat foundations, also called raft foundations, have large areas with multiple supported columns. Usually, all the columns in the building are supported on one foundation. Mat foundations are preferred when the soil has a low bearing capacity.

All the loads are distributed to a large area, which reduces the stress exerted on the low-bearing capacity soil. Mat foundations are economic in situations where piles cannot be constructed and spread footings are not practical, such as the case with low-rise, multistory buildings, if the top layers of the soil are weak.



Picture 37: mat foundations

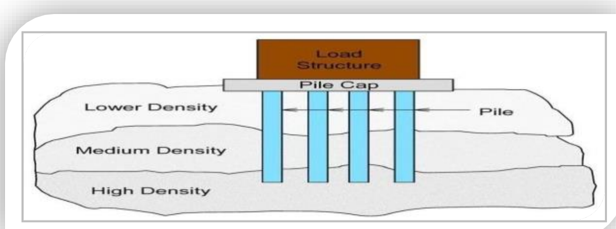
Piles Foundations

A pile is a long cylinder of a strong material such as concrete that is pushed into the ground to act as a steady support for structures built on top of it.

Pile foundations are used in the following situations:

1- When there is a layer of weak soil at the surface. This layer cannot support the weight of the building, so the loads of the building have to bypass this layer and be transferred to the layer of stronger soil or rock that is below the weak layer.

2 - When a building has very heavy, concentrated loads, such as in a high rise structure, bridge, or water tank.

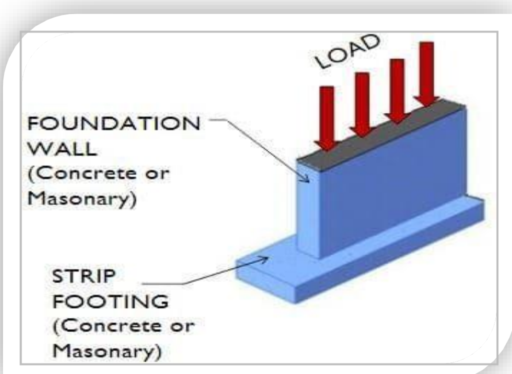


Picture 38: piles foundations

Strip Foundations

Strip foundations consist of a continuous strip, usually of concrete, formed centrally under load bearing walls. This continuous strip serves as a level base on which the wall is built and is of such a width as is necessary to spread the load on the foundations to an area of subsoil capable of supporting the load without undue compaction. Concrete is the material principally used today for foundations as it can
readily be placed, spread and levelled in foundation trenches, to provide a base for walls, and it develops adequate compressive strength as it hardens to support the load on foundations. Before Portland cement was manufactured, strip foundations of brick were common, the brick foundation being built directly off firm subsoil or built on a bed of natural stones.

The width of a concrete strip foundation depends on the bearing capacity of the subsoil and the load on the foundations.



Picture 39: strip footing

Combined Foundations

Combined footings are provided when distance between two columns is small and soil bearing capacity of soil is lower and their footings overlap with each other.
When two columns are close together and separate isolated footings would overlap, in such case, it is better to provide a combined footing than isolated footing.

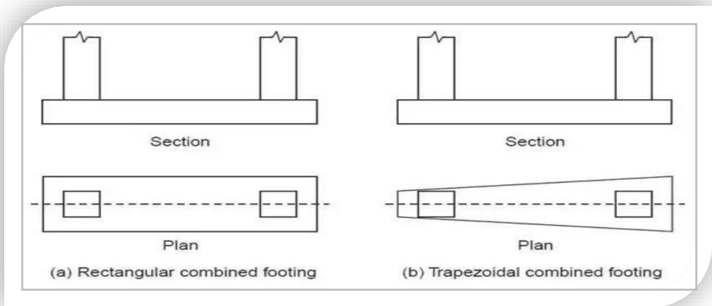
Following are the reasons when combined footings are preferred:

- The distance between two columns is small and when soil bearing capacity of soil is lower and their footings overlap with each other.

- When one column is close to a property line or sewer pipe, the Centre of gravity of column will not coincide with footing. In such cases, it is necessary to provide combined this footing with that of the adjacent internal column.

- Dimensions of one side of footing are restricted to some lower value so that column footings may be combined.

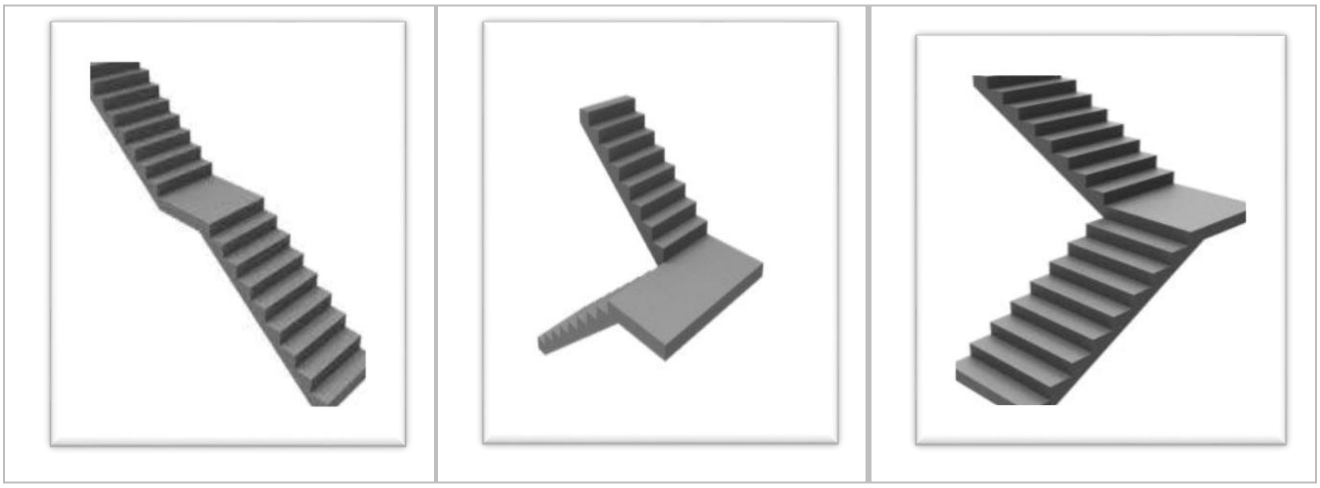
The combined footing may be rectangular, trapezoidal. The ultimate aim is to get uniform pressure distribution under the entire area of the footings. To achieve this, the centre of gravity of the footing area should coincide with the centre of gravity of the total loads of the two or more columns.



Picture 40: combined foundations

3 – 4 – 6: Stairs

Stairs give access from floor to floor. The space/room housing stairs is called staircase, Stairs consists of many steps arranged in a single flight or more number of flights.



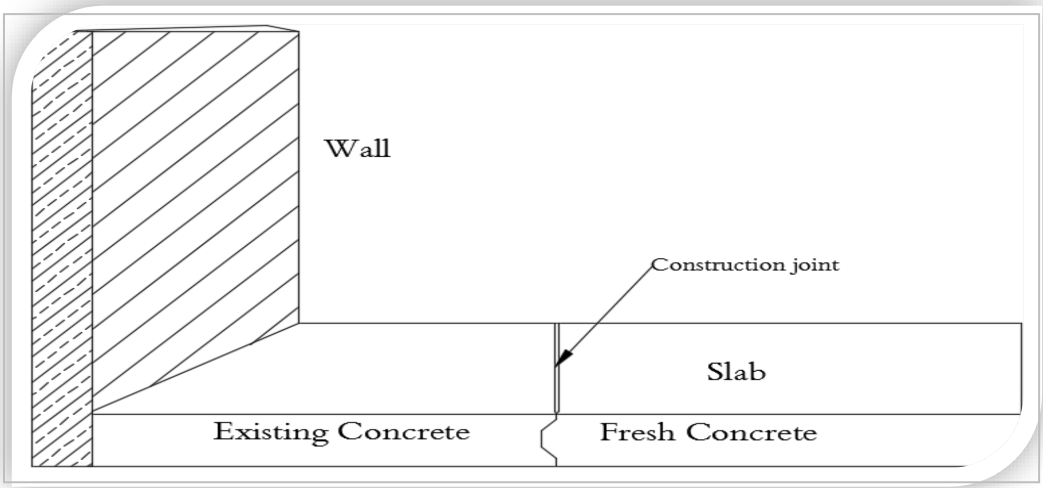
Picture 41: stairs

3.5 Expansion joints

Expansion joint is a joint provided in a building to mitigate the risk of crack formation due to thermal expansion. The joint allows separation of building that will allow the building to expand and release stresses thereby preventing release of stresses by cracking.

The distance between expansion joints can be determined for normal installations

- From 40 to 45 in the temperate regions as in Palestine
- From 30 to 35 m in hot areas.



Picture 42: Expansion joints

Chapter 4
Structural design

- **4.1 Introduction of Structural Design**
- **4.2 Design Method and Requirements**
- **4.3 Materials that used**
- **4.4 Design of one-way slid slab**
- **4.5 Design of one-way ribbed slab**
- **4.6 Design of rib R7as a reinforced concrete (T-Section)**
- **4.7 Design of Beam B6**
- **4.8 Design of column C10**
- **4.9 Design of Footing F10**
- **4.10 Design of stair**
- **4.11 Design of shear wall**

4.1 Introduction of Structural Design

Structural design is the methodical investigation of the stability, strength, and rigidity of structures. The basic objective in structural analysis and design is to produce a structure capable of resisting all applied loads without failure during its intended life.

The Romans are the first users of the Plain Concrete in the history of about two thousand years and have been used in most of their buildings for ease of formation and the possibility of carrying out them with trained workers with simple training.

Concrete is a mixture of raw materials consisting of sand, grit (or a tooth or broken stone) and cement, with the addition of water to them. And when mixed well, a coherence process between them is called the time of doubt. And concrete has many characteristics that are distinguished from other materials; it takes a solid and solid form with time gradually, begins with primary suspicion and ends with final suspicion. It is also very resistant to Compression, but at the same time, it is very weak in its resistance to tensile. Therefore, Plain concrete is never used in places where tensile stresses occur.

To solve this problem, Steel is placed and it is excellent resistance to tensile forces and pressure forces. While long steel can resist all tensile forces, concrete does not withstand all pressure forces if its sections are thin and occur as a result of this denting of concrete.

Therefore, we find that a mixture of concrete and steel gives an ideal material to resist the various stresses that affect it. This compound is what is known as reinforced concrete

4.2 Design Method and Requirements

The design strength provided by a member is calculated in accordance with the requirements and assumptions of ‘’ACI 318-14 ‘’ & Jordan code.

- ✓ Strength design method: -

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

.

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

The strength design method is expressed by the following,

<u>Strength provided ≥ strength required to carry factored loads.</u>

Factored loads: -

The factored loads for members in our project are determined by:-

$W_u = 1.2\ D_L + 1.6\ L_L$ “ ACI 318-14 “

4.3 Materials that used

Concrete: - " B300 "

$f\acute{c} = 30\ MPa$ for circular section

But, for rectangular section ($f\acute{c} = 30 * 0.8 = 24\ MPa$).

Reinforcement steel: -

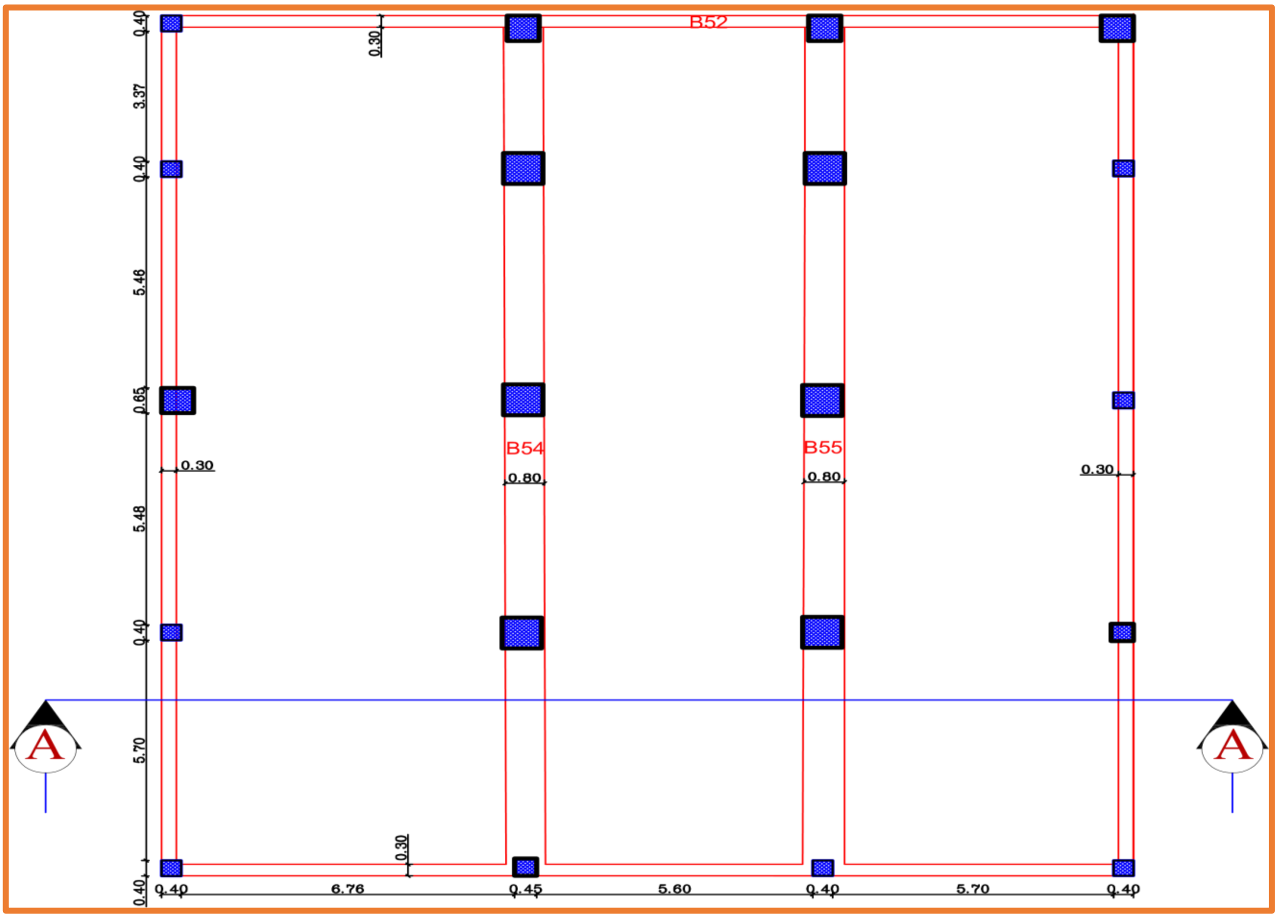
The specified yield strength of the reinforcement ($Fy = 420\ MPa$).

4.4 Design of one-way solid slab

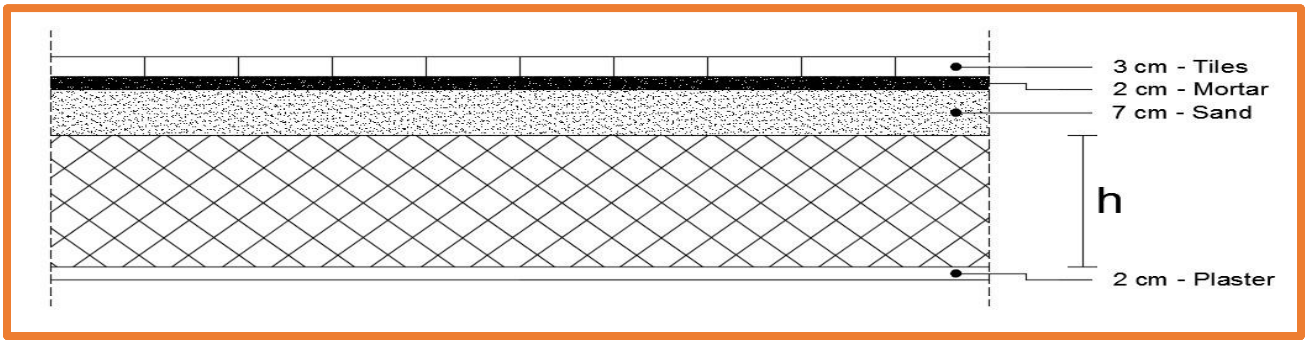
$f\acute{c}$ = 24 Mpa **fy = 420 Mpa** **C = 20mm** **Ø = 12mm**

γ_{snad} = 16 kN/m^3 **γ_{mortar} = 22 kN/m^3** **γ_{tiles} = 23 kN/m^3**

$\gamma_{plaster}$ = 22 kN/m^3 **Live load = 2.5 kN/m^2** **Partitions = 2.5 kN/m^2**



TOP View



SECTION (A-A)

Solution:

(A) Classification of slab one way or two-way solid slab

From top view of the slab

SO $\frac{Ly}{lx} = \frac{21.85}{7.19} =$ 3.038> 2 one-way solid slab

And $\frac{Ly}{lx} = \frac{21.85}{6.02} =$ 3.62 > 2 one-way solid slab

And $\frac{Ly}{lx} = \frac{21.85}{6.10} =$ 3.58 > 2 one-way solid slab

Limitation of Deflection:

Minimum (h) = 7.23/24 = 0.32 m

→ Select h = 35 cm #

Loads:

Dead loads for 1m strip:

Slab = 25*0.35*1 = 7.5 kN/m
Sand = 0.07*16*1 = 1.12 kN/m
Mortar = 0.02*22*1 = 0.44 kN/m
Tiles = 0.03*23*1 = 0.69 kN/m
Plaster = 0.02*22*1 = 0.44 kN/m
Partition = 2.5*1 = 2.5kN/m

Dead loads = Sum of all above loads =12.69 kN/m #

Live load for 1m strip:

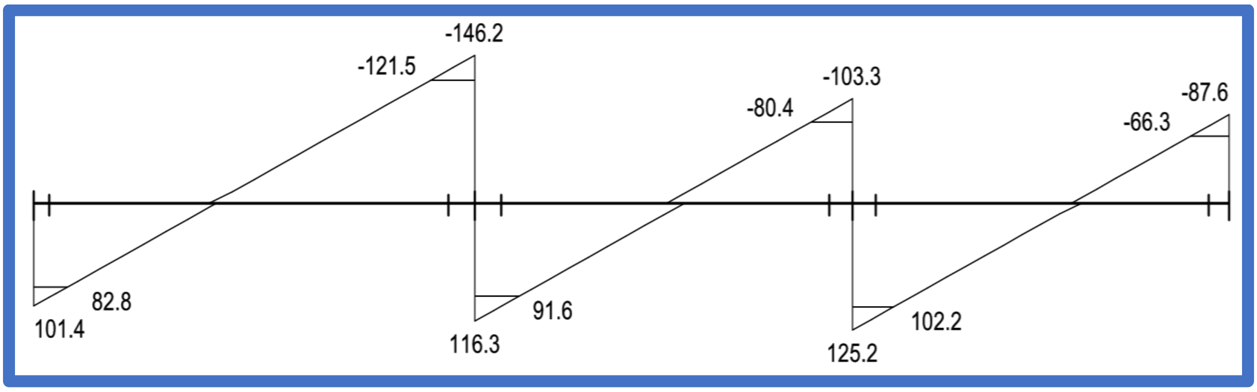
Live Load = 5 *1 = 5 KN/m

Factored load (q_u):

q_u = 1.2*12.69 = 15.228 kN/m
= 1.6*5 = 8 kN/m

❖ Shear Force envelope

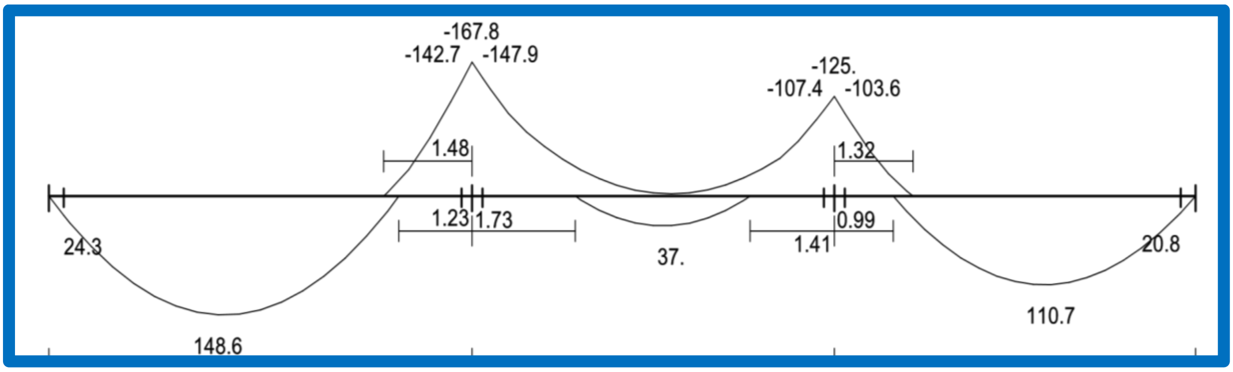
drawn values only at the critical section of shear force at a distance (d) from the face of support



Picture 43: Shear envelope of solid slab

❖ Bending Moment Envelope

design section at the face of middle support



Picture 44: Bending Moment envelope of solid slab

➢ Design of Shear Force

d = 350 -20 – 12/2 = 324 mm

Maximum Vu from shear envelope diagram = 121.5kN

Ø *VC =0.75 *$\frac{1}{6} * \sqrt{fć}$ *bw*d

= 0.75 *$\frac{1}{6} * \sqrt{24}$ *1000*324 =198.40 KN > Max Vu = 121.5 KN

So, No shear reinforcement is required #

➢ Design of Bending Moment

Design of Negative moment at support (B) MU= 147.9 KN.m

$$Kn = \frac{Mu/\,Ø}{b*d^2} = \frac{147.9*10^6/\,0.9}{1000*324^2} = 1.56MPa$$

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*1.56*20.6}{420}}\right) = 0.00386$$

Asreq = $\rho \times$ b× d = 0.00386× 1000× 324 = 1250.64 mm^2

As(min) = 0.0018 * 1000 * 350 = 630 mm^2

Asreq = 1250.64 mm^2 > As(min) = 630 mm^2

Select Ø 16 /15 With AS=1340.41 mm^2

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * b

1340.4*420=0.85*24*a*1000

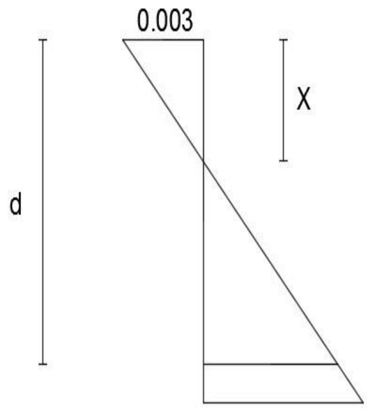
a= 2.68 mm.

Since

fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 2.68/ 0.85 = 3.15 mm



From Strain Diagram:

$$\frac{0.003}{3.15} = \frac{0.003 + \varepsilon s}{324}$$

ε_s=0.30 > 0.005

So,

Ø = 0.9 ………. (OK)

Design of Negative moment at support (c) MU= 107.4 KN.m

Kn = $\frac{Mu\,/Ø}{b*d^2} = \frac{107.4*10^6/\,0.9}{1000*324^2} = \mathbf{1.13Mpa}$

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\boldsymbol{\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*1.13*20.6}{420}}\right) = 0.00276}$$

Asreq = ρ × b× d = 0.00276× 1000× 324 = 897.3 mm²

As(min) = 0.0018 * 1000 * 350 = 630 mm²

Asreq **= 897.3 mm² > As(min) = 630 mm²**

SELECT Ø 12/15 With AS=1026.25 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * b

1340.4*420=0.85*24*a*1000

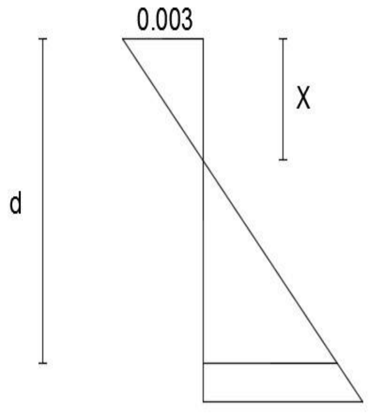
a= 2.68 mm.

Since

fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 2.68/ 0.85 = 3.15 mm



From Strain Diagram:

$$\frac{0.003}{3.15} = \frac{0.003 + \varepsilon s}{324}$$

ε_s=0.30 > 0.005

So,

Ø = 0.9 ………. (OK)

Design of Positive moment of span (1) Mu= 148.6

$$\textbf{Kn} = \frac{Mu/\,\emptyset}{b*d^2} = \frac{148.6*10^6/\,0.9}{1000*324^2} = 1.57\text{Mpa}$$

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*1.57*20.6}{420}}\right) = 0.00389$$

Asreq $= \rho \times b \times d$ = 0.00389× 1000× 324 = 1260.36 mm²

As(min) = 0.0018 * 1000 * 350 = 630 mm²

Asreq = 1260.36 mm² > As(min) = 630 mm²

SELECT Ø 16 /15 With AS=1340.41 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc’ * a * b

1340.4*420=0.85*24*a*1000

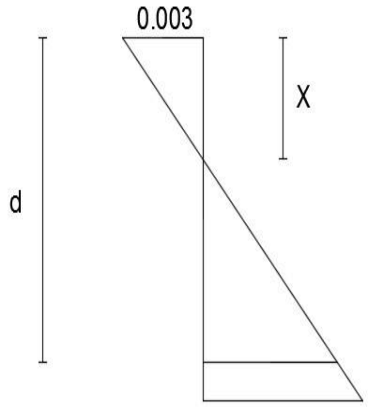
a= 2.68 mm.

Since

fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 2.68/ 0.85 = 3.15 mm



<u>From Strain Diagram:</u>

$$\frac{0.003}{3.15} = \frac{0.003 + \varepsilon s}{324}$$

ε_s=0.30 > 0.005

So,

<u>Ø = 0.9 …………... (OK)</u>

<u>Design of Positive moment of span (2) Mu= 37 kN.m</u>

Kn = $\frac{\boldsymbol{Mu/\ Ø}}{\boldsymbol{b*d^2}} = \frac{37*10^6/\ 0.9}{1000*324^2} = 0.39$Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$\boldsymbol{\rho} = \frac{\mathbf{1}}{\boldsymbol{m}}\left(\mathbf{1} - \sqrt{\mathbf{1} - \frac{\mathbf{2}*\boldsymbol{Kn}*\boldsymbol{m}}{\boldsymbol{fy}}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*0.39*20.6}{420}}\right) = 0.00941$

Asreq = $\boldsymbol{\rho}$ × b× d = 0.00389× 1000× 324 = 305.06 mm²

As(min) = 0.0018 * 1000 * 350 = 630 mm²

Asreq = 305.06 mm² < As(min) = 630 mm²

SELECT Ø 12/15 With AS=753.98 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * b

753.98*420=0.85*24*a*1000

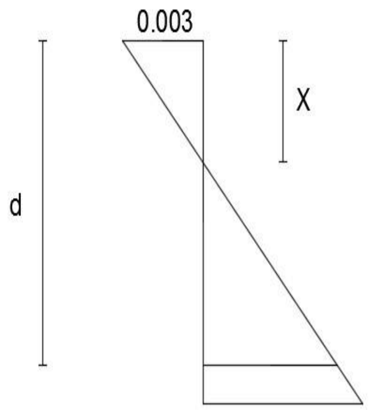
a= 15.52 mm.

Since

fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 15.52/ 0.85 = 18.26 mm



From Strain Diagram:

$$\frac{0.003}{15.52} = \frac{0.003 + \varepsilon s}{324}$$

ε_s=0.059 > 0.005

So,

Ø = 0.9 …………..… (OK)

Design of Positive moment of span (3) Mu= 110.7 kN.m

Kn = $\frac{Mu/\text{Ø}}{b*d^2} = \frac{110.7*10^6/0.9}{1000*324^2} = 1.17\text{Mpa}$

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*1.17*20.6}{420}}\right) = 0.00287$$

Asreq = ρ × b× d =0.00287× 1000× 324 = 931.46 mm^2

As(min) = 0.0018 * 1000 * 350 = 630 mm^2

Asreq = 931.46 mm^2 >As(min) = 630 mm^2

SELECT Ø 14/15 With AS=1026.26 mm^2

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * b

1026.26*420=0.85*24*a*1000

a= 21.12 mm.

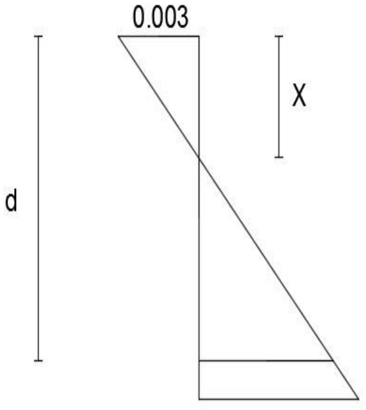
Since

fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 21.12/ 0.85 = 24.8mm

From Strain Diagram:

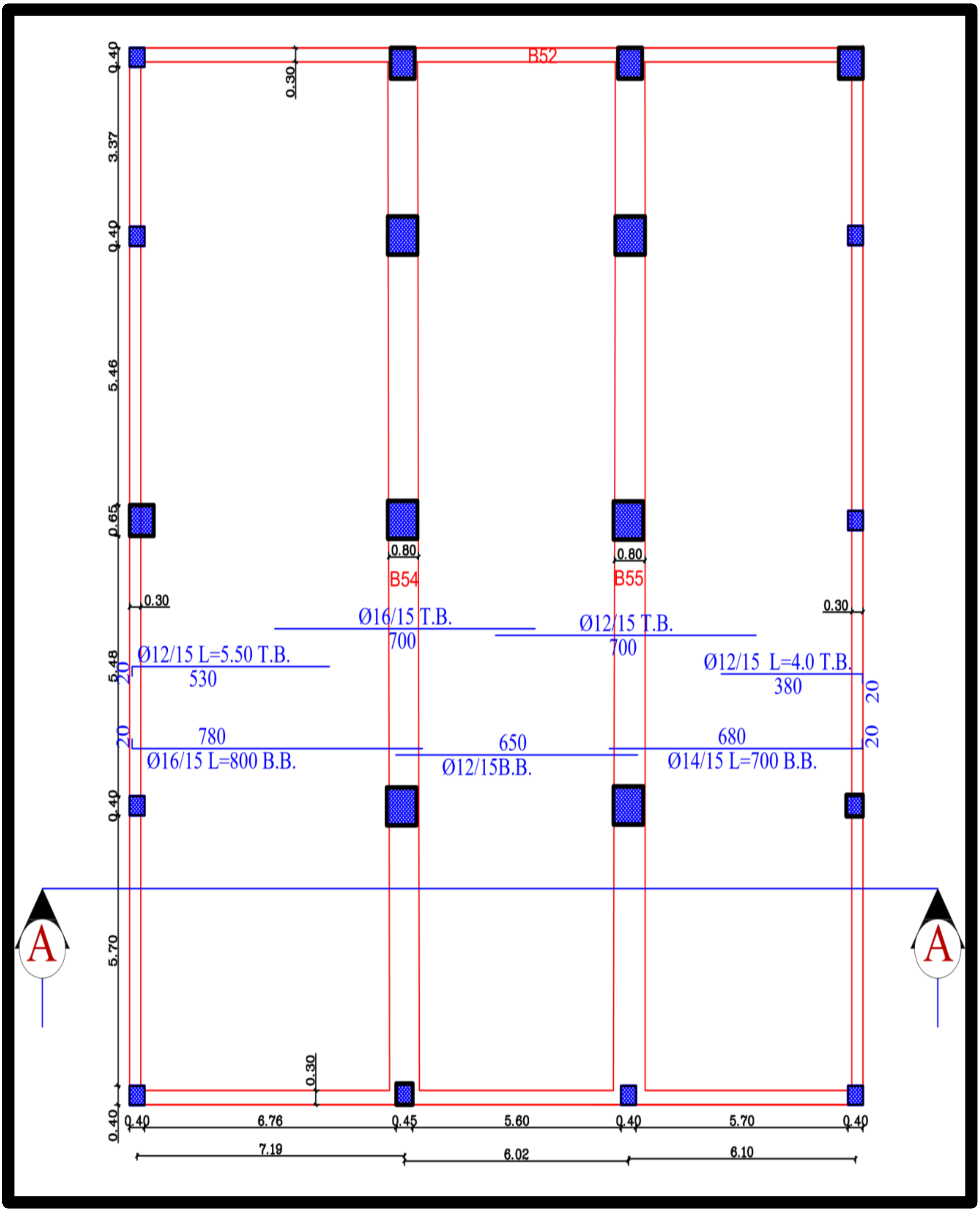


$$\frac{0.003}{24.8} = \frac{0.003 + \varepsilon s}{324}$$

ε_s=0.036 > 0.005

So,

<u>Ø = 0.9 ………….…. (OK)</u>



Picture 45: Reinforcement of solid slab

4.5 Design of one-way ribbed slab

➢ Check the minimum thickness of slab

Minimum thickness				
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

Table3: Check of Minimum Thickness of Slabs.

Here, the next system that we will design it:

Picture 46: system that we will design

h min (one end conte) = L/18.5 = 700/18.5 = 37.83 cm

h min (both end conte) = L/21 = 745 /21 = 35.47 cm

We select from one-way ribbed slab, The Thickness of Ribbed slab= 35 cm

Select 27 cm Block + 8 cm Topping.

Design of Topping

The loads that act on the topping strip:

Dead Loads

NO	Parts of topping	Calculation
1	Tiles	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	2.5 * 1 = 2.5 KN/m

Sum =7.04KN/m

Table4: Dead load of topping

Live Load: -

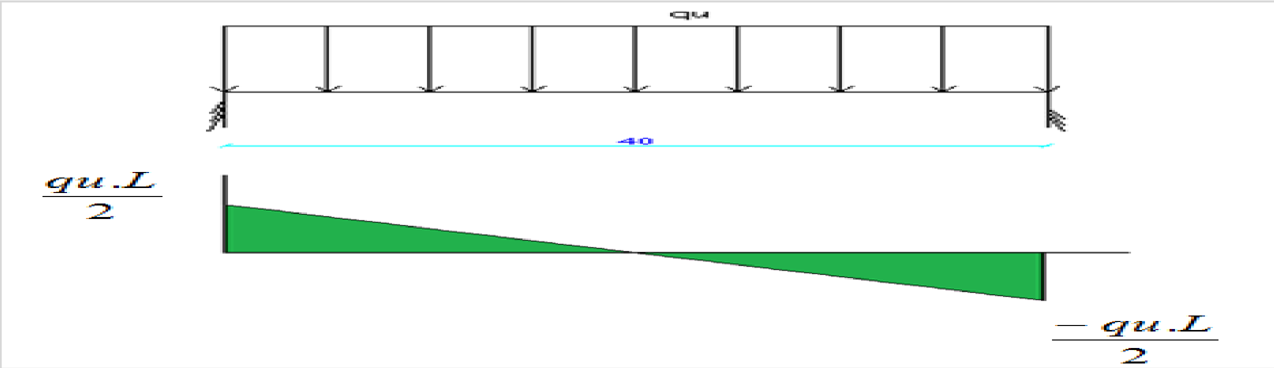
LL = 5 KN/m2 (by Jordan code for shop rooms).

LL=5KN/m2×1m=5KN/m

Factored Load: -

$$q_U = 1.2 \times 7.04 + 1.6 \times 5 = 16.448 \text{ KN/m}$$

- **Design of topping as a plain concrete section:**



System & Analysis:

Vu= $\frac{\boldsymbol{qu*l}}{\mathbf{2}} = \frac{16.448*0.4}{2} =$ 3.28 KN

Mu= $\frac{\boldsymbol{ql^2}}{\mathbf{12}} = \frac{16.448*0.4^2}{12} =$ 0.219 KN.m

❖ **Design of Shear Force**

Plain concrete section, one-way shear:

Ø * Vc = Ø * 0.11 * λ * $\sqrt{f\acute{c}}$ * bw * h

= Ø * 0.11 * λ * $\sqrt{24}$ *1000* 80=25.87 kN > Vu → **SAFE**

- **<u>Design of Bending Moment:</u>**

"b = 1 m & h = 8 cm" Plain concrete section:

$$\text{Ø} * \text{Mn} = 0.6 * 0.42 * \sqrt{f\acute{c}} * \frac{b * h^2}{6}$$

$$= 0.6 * 0.42 * \sqrt{24} * \frac{1000 * 80^2}{6} = 1.32 \text{ kN.mv} > \text{Mu} \quad \rightarrow \textbf{SAFE}$$

"The magnitude of (λ) is 1.0 for normal weight concrete"

So, Plain Concrete Section is SAFE #

Minimum (As) = 0.0018 * Ag

= 0.0018 * b * h

= 0.0018 * 100 * 8

= 1.44 cm^2/m

<u>→ Select Mesh Ø8/20cm in both directions #</u>

As = (π*8^2/4) *(100/20) = 2.5 cm^2/m > min As = 1.44 cm^2/m

4.6 Design of rib R7as a reinforced concrete (T-Section)

Check of the selected dimensions.

- ht = 8cm
- bw = 12cm ≥ 10cm
- hr = 35 ≤ 3.5(12) = 42cm
- LC = 40 ≤ 75cm

✓ Load Calculation: -

1 -Dead Load: -

No.	Parts of Rib	Calculation
1	Tiles	0.03*23*0.52 = 0.359 KN/m/rib
2	Mortar	0.03*22*0.52 = 0.343 KN/m/rib
3	Coarse Sand	0.07*17*0.52 = 0.62 KN/m/rib
4	Topping	0.08*25*0.52 = 1.04 KN/m/rib
5	RC. Rib	0.27*25*0.12 = 0.81 KN/m/rib
6	Hollow Block	0.27*10*0.4 = 1.08 KN/m/rib
7	plaster	0.03*22*.52= 0.343 KN/m/rib
8	partitions	2.5*0.52= 1.3 KN/m/rib
		Sum = 5. 895KN/m/rib

Table5: Dead Load Calculation of Rib

Dead Load / rib = 5.895 KN/m

Live load = 5KN/m2

Live load /rib =5 KN/m^2 × 0.52m = 2.6KN/m.

Effective Flange Width (bE)

b_e for T- section is the smallest of the following:

1 - b_e= L / 4 = 636/ 4 =159cm

2 - b_e= 12 + 16 t = 12 + 16 (8) = 140 cm

3 - be ≤ center to center spacing between adjacent beams = 52cm

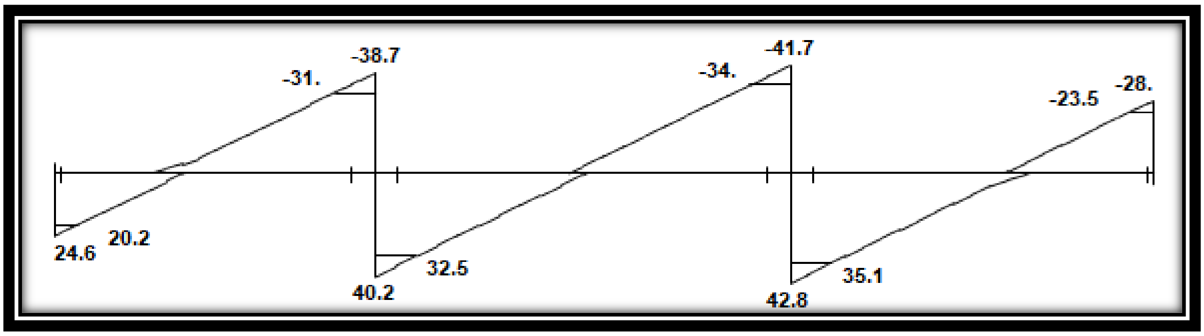
Select (be) for T-section = 52cm

Factored loads

Dead Load = 1.2 * 5.895 +1.6 * 2.6 = 11.234KN /m

d = 350– 20 –10 – (12/2) = 314 mm

- **Design of Shear Force:**



Picture 47: Shear envelope of Rib

<u>Maximum (Vu) at the critical Section = 35.1 kN</u>

1.1* Ø * Vn = 1.1 * Ø * $\frac{1}{6} * \sqrt{f\acute{c}}$ ***bw*d** $\le vu$=35.1KN

=1.1 *0.75 *$\frac{1}{6} * \sqrt{24}$ *120*314=25.38KN <VU =35.1KN

<u>So, shear reinforcement is required according to (ACI)</u>

CASE 3:

Ø * Vc < Vu $\le Ø * Vc + Ø * Vs_{min}$

Ø * Vc = 0.75*$\frac{1}{6} * \sqrt{f\acute{c}}$ ***bw*d** = 0.75* $\frac{1}{6} * \sqrt{24}$ *120*314=23.07KN

Ø*Vs_{min}= 0.75*$\frac{1}{16} * \sqrt{f\acute{c}}$ ***bw*d** = 0.75* $\frac{1}{16} * \sqrt{24}$ *120*314=8.65 KN

OR

Ø *Vs_{min}=0.75*$\frac{1}{3}$ ***bw*d**=0.75* $\frac{1}{3}$ *120*314=9.4 KN… **<u>Controlled</u>**

Ø * Vc + Ø *Vs_{min} = 23.07KN + 9.4 KN = 32.47KN <Vu =35.1 KN

CASE 4:

$Ø * Vc + Ø * Vs_{min}$**< Vu** $\le Ø * Vc + Ø \frac{1}{3} * \sqrt{f\acute{c}}$ ***bw*d**

0.75*$\frac{1}{3} * \sqrt{f\acute{c}}$ ***bw*d**=0.75* $\frac{1}{3} * \sqrt{24}$ *120*314=46.15 KN

$Ø * Vc + Ø \frac{1}{3} * \sqrt{f\acute{c}}$ ***bw*d** = 23.07KN+46.15 KN = 69.22KN > Vu=35.1KN

Vs = $\frac{Vu - Ø * Vc}{Ø} = \frac{35.1 - 23.07}{0.75} = 16.04\ KN$

Av = # of legs*As= 2*$\frac{\pi * 10^2}{4}$ =157mm^2

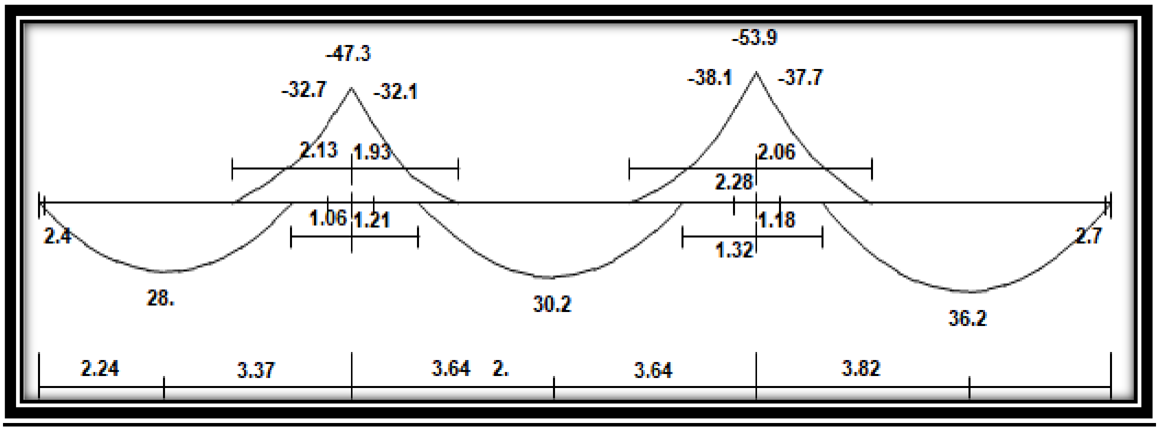
$$S_{req} = \frac{Av * fy * d}{Vs} = \frac{157 * 420 * 314}{16.04} = 1290\ mm$$

$$S_{req} \leq \frac{d}{2} = \frac{314}{2} = 157mm$$

$$\leq 600mm$$

Select Ø10/15cm

❖ **Design of moment:**



Picture 48: Moment envelope of Rib

Design positive moment:

✓ Design of positive moment in span (3)– Bottom Reinforcement:

Span (1), maximum Mu⁺ = 36. 2KN.m

Check (a ≤ t):

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć * t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu+ = 36.2 kN.m **→ a < t**

Design of rectangular section: (b = bE)

Kn = $\frac{\boldsymbol{Mu/\text{Ø}}}{\boldsymbol{b*d^2}} = \frac{36.2*10^6/0.9}{520*314^2} = 0.784$ Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.784*20.6}{420}}\right) = 0.0019$

As (req) = ρ * bE *d = 0.0019 * 520 * 314 = 310.232 mm².

Check As(min):

As (min)=$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm². …………« **controlled**

Or

As (min)=$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$mm².

So, As = 310.232 mm² > As (min) = 125.6 mm²

→ Select 2 Ø14 with As = 310 mm².

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

310*420=0.85*24*a*520

a= 12.27 mm.

Since

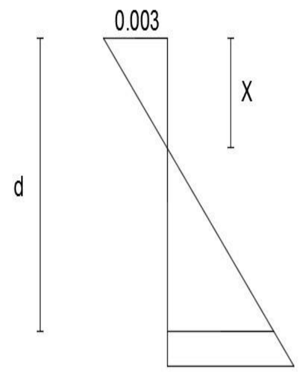
Fc' = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 12.27 / 0.85 = 14.44 mm

<u>From Strain Diagram</u>:

$$\frac{0.003}{14.44} = \frac{0.003+\varepsilon s}{314}$$



ε_S =0.0622 >0.005

So,

<u>Ø = 0.9 ……………… (OK)</u>

✓ <u>Design of positive moment in span (2) – Bottom Reinforcement:</u>

<u>Span (1), maximum Mu⁺ = 30. 2KN.m</u>

Check (a ≤ t):

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć * t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu^+ = 30.2 kN.m **<u>→ a < t</u>**

<u>Design of rectangular section: (b = bE)</u>

KN = $\frac{Mu/\text{Ø}}{b*d^2} = \frac{30.2*10^6/0.9}{520*314^2} =$ 0.654 Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*0.654*20.6}{420}}\right) = 0.00158$$

As (req) = ρ * bE *d = 0.00158 * 520 * 314 = 257.98 mm².

<u>Check As(min):</u>

As (min) = $\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 =$ 125.6 mm². « controll

Or

As (min)=$0.25 * \frac{\sqrt{f\acute{c}}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 =$ 109.87 mm².

So, As = 257.98 mm² > As (min) = 125.6 mm²

<u>→ Select 2 Ø14 with As = 310 mm²</u>

<u>Check Strain:</u>

T = C

As * Fy = 0.85 * Fc' * a * bE

310*420=0.85*24*a*520

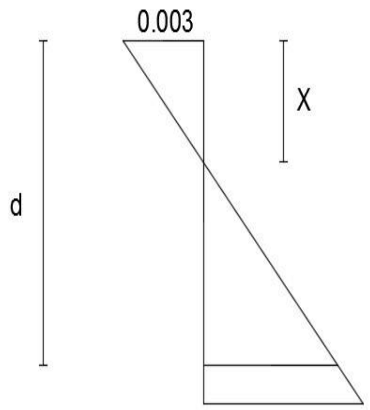
a= 12.27 mm.

Since

fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 12.27 / 0.85 = 14.44 mm



From Strain Diagram:

$$\frac{0.003}{14.44} = \frac{0.003+\varepsilon s}{314}$$

ε_S=0.0622 >0.005

So,

Ø = 0.9 …………… (OK)

✓ Design of positive moment in span (1) – Bottom Reinforcement:

Span (1), maximum Mu^+ = 28KN.m

Check (a ≤ t):

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć * t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu^+ = 30.2 kN.m **→ a < t**

Design of rectangular section: (b = bE)

Kn = $\frac{Mu/Ø}{b*d^2} = \frac{28*10^6/0.9}{520*314^2} = 0.606$ Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.606*20.6}{420}}\right) = 0.00146$$

As (req) = ρ * bE *d = 0.00146 * 520 * 314 = 238.38 mm².

Check As(min):

As (min)=$\frac{\mathbf{1.4}}{\boldsymbol{fy}} * \boldsymbol{bw} * \boldsymbol{d} = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

As (min)=$\mathbf{0.25} * \frac{\sqrt{\mathbf{f\acute{c}}}}{\boldsymbol{fy}} * \boldsymbol{bw} * \boldsymbol{d} = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ mm².

So, As = 238 mm² > As (min) = 125.6 mm²

→ Select 2 Ø14 with As = 310 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc’ * a * bE

310*420=0.85*24*a*520

a= 12.27 mm.

Since

fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 12.27 / 0.85 = 14.44 mm

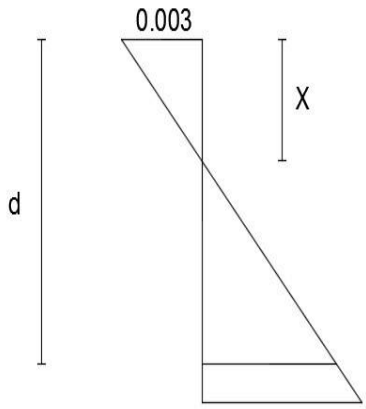
From Strain Diagram:

$$\frac{0.003}{14.44} = \frac{0.003+\varepsilon s}{314}$$

ε_S = 0.0622 >0.005

So,

Ø = 0.9 ……………..…. (OK)



Design of negative moment:

Design as a rectangular section with (t = 120mm)

✓ **Design of negative moment at support (B) – Top Reinforcement:**
Support (B), minimum Mu = -32.7 kN.m section with bE = bw

Kn = $\frac{\boldsymbol{Mu}/\text{Ø}}{\boldsymbol{b*d^2}} = \frac{32.7*10^6/0.9}{120*314^2} = 3.077$ Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{\mathbf{1}}{\boldsymbol{m}}\left(\mathbf{1}-\sqrt{\mathbf{1}-\frac{\mathbf{2}*\boldsymbol{Kn}*\boldsymbol{m}}{\boldsymbol{fy}}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*3.077*20.6}{420}}\right) = 0.00798$$

As (req) = ρ * bE *d = 0.00798 * 120 * 314 = 297.3 mm².

Check As(min):

As (min)=$\frac{\mathbf{1.4}}{\boldsymbol{fy}} * \boldsymbol{bw} * \boldsymbol{d} = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

As (min)=$\mathbf{0.25} * \frac{\sqrt{f\acute{c}}}{\boldsymbol{fy}} * \boldsymbol{bw} * \boldsymbol{d} = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ mm².

So, As = 297.3 mm² > As (min) = 125.6 mm²

→ Select 2 Ø14 with As = 310 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

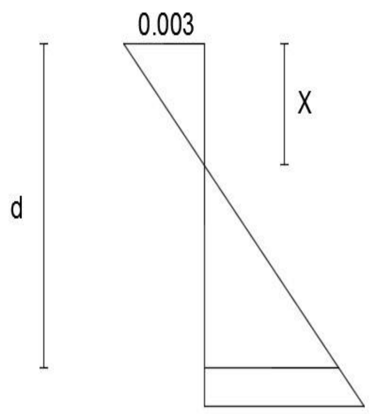
310*420=0.85*24*a*520

a= 12.27 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 12.27 / 0.85 = 14.44 mm



From Strain Diagram:

$$\frac{0.003}{14.44} = \frac{0.003+\varepsilon s}{314}$$

ε_s = 0.0622 >0.005

So,

Ø = 0.9 ……………. (OK)

- ✓ **Design of negative moment at support (c) – Top Reinforcement:**

Support (B), minimum Mu = -32.7 kN.m section with bE = bw

KN = $\frac{Mu/\varnothing}{b*d^2} = \frac{38.1*10^6/0.9}{120*314^2} = 3.58$ Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*3.58*20.6}{420}}\right) = 0.009$$

As (req) = ρ * bE *d = 0.009* 120 * 314 = 340 mm².

Check As(min):

As (min)=$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

As (min)=$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ mm².

So, As = 125.6 mm² > As (min) = 109.87mm²

→ Select 2 Ø16 with As = 400 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

400*420=0.85*24*a*520

a= 15.84 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 15.84 / 0.85 = 18.63 mm

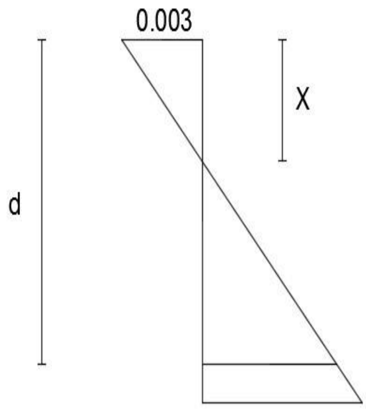
From Strain Diagram:

$$\frac{0.003}{18.63} = \frac{0.003+\varepsilon s}{314}$$

ε_s=0.0476 >0.005

So,

Ø = 0.9 …………… (OK)



4.7 Design of Beam B30

Load Calculations: -

Dead Load Calculations for Beam The distributed Dead and Live loads acting upon Beam can be defined from the support reactions of the R3

Dead Load: -

No.	Parts of Beam	calculation
1	Tiles	0.03*23*0.8 = 0.552 KN/m
2	Mortar	0.03*22*0.8 = 0.528 KN/m
3	Coarse Sand	0.07*17*0.8 = 0.952KN/m
5	RC. Beam	0.35*0.8*25 = 9 KN/m
7	plaster	0.03*22*0.8 = 0.528 KN/m
8	partitions	2.5*0.8= 2 KN/m

Sum = 13.5KN/m

Table6: Dead Load Calculation of Beam

Factored					
DeadR	7.77	36.29	39.28	44.88	15.73
LiveR	7.59	25.23	28.16	30.04	11.12
MaxR	15.36	61.52	67.44	74.92	26.85
MinR	5.05	42.98	49.52	56.56	14.47
Service					
DeadR	6.47	30.24	32.73	37.4	13.1
LiveR	4.75	15.77	17.6	18.77	6.95
MaxR	11.22	46.01	50.33	56.17	20.05
MinR	4.78	34.42	39.13	44.7	12.32

Picture 49: Reaction of Rib 3

From Rib 3:

DL = (32.73/ 0.52) = 62.94 KN / m

Total DL = 62.94 + 1.2 * 13.5 = 79.14 KN / m

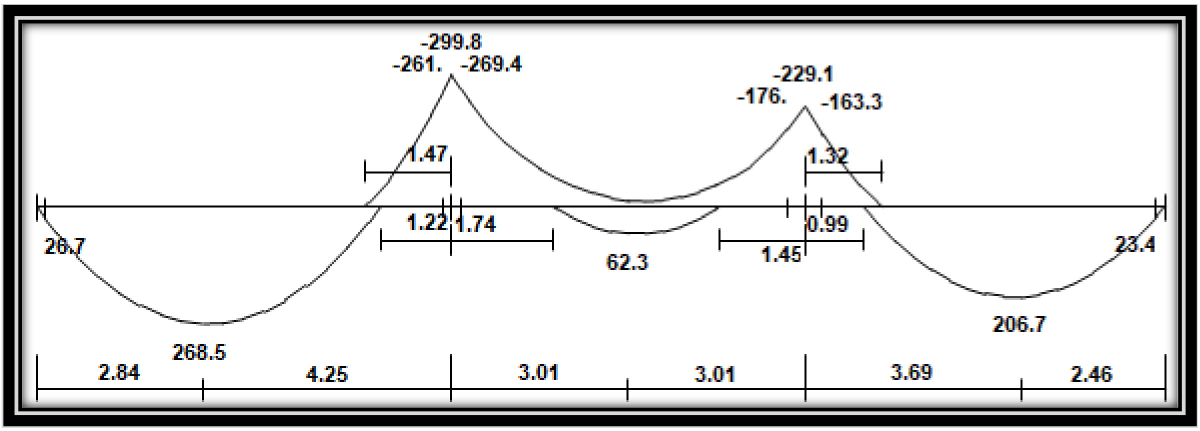
Live Load calculations for Beam: -

LL = 17.6 / 0.52 = 33.84 KN/m.

Nominal Total live load =5 * 0.8 = 4 KN/m

Total LL = 33.84 + 1.6 * 4 = 40.24 KN/m

Design of moment for Beam:



Picture 50: Moment of Envelope of Beam

Factored				
DeadR	137.34	353.06	307.01	119.51
LiveR	45.58	117.15	107.28	41.04
MaxR	182.92	470.21	414.29	160.56
MinR	133.91	391.3	342.74	115.17
Service				
DeadR	114.45	294.22	255.84	99.6
LiveR	28.49	73.22	67.05	25.65
MaxR	142.94	367.44	322.89	125.25
MinR	112.31	318.12	278.17	96.88

Picture 51: Factored of Beam

✓ Design of Positive Moment Mu = 268. 5KN.m

Assume bar diameter ø 16 for main positive reinforcement

d =450-40-10-16/2=392mm

$$\textbf{Kn} = \frac{Mu/\varnothing}{b*d^2} = \frac{268.5*10^6/0.9}{800*392^2} = 2.43 \text{ Mpa}$$

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*2.43*20.6}{420}}\right) = 0.0062$$

As (req) = ρ * b *d = 0.0062 * 800 * 392 = 1944.32 mm².

Check As(min):

As (min)=$\frac{1.4}{fy} * b * d = \frac{1.4}{420} * 800 * 392 = 1045.3$ mm². « control

Or

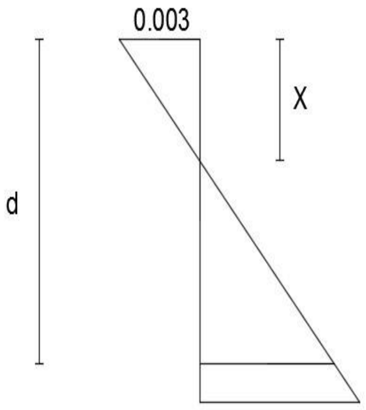
As (min)=$0.25 * \frac{\sqrt{f\acute{c}}}{fy} * b * d = 0.25 * \frac{\sqrt{24}}{420} * 800 * 392 = 914.48$ mm².

So, As = 1944.32 mm² > As (min) = 1045.3 mm²

As ø 16 =201 mm²

$N_{req} = \frac{AS_{req}}{AS\# \ BARS} = \frac{1944.32}{201} = 9.67 basrs$

Select 10 ø 16 AS = 2010.62 mm²



Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * b

2010.62*420=0.85*24*a*800

a= 51.74 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 51.74 / 0.85 = 60.87 mm

From Strain Diagram:

$\frac{0.003}{60.87} = \frac{0.003+\varepsilon s}{392}$

ε_s=0.0163>0.005

So,

Ø = 0.9 … (OK)

✓ **Design of Positive Moment Mu = 62. 3KN.m**

Assume bar diameter ø 16 for main positive reinforcement

d =450-40-10-16/2=392mm

Kn = $\frac{Mu/\text{Ø}}{b*d^2} = \frac{62.3*10^6/0.9}{800*392^2} = 0.56$ Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho=\frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right)=\frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.56*20.6}{420}}\right)=0.00135$$

As (req) = ρ * b *d = 0.00135* 800 * 392 = 426.42 mm².

Check As(min):

As (min)=$\frac{1.4}{fy}*b*d=\frac{1.4}{420}*800*392=1045.3$ mm².« controll

Or

As (min)=$0.25*\frac{\sqrt{fć}}{fy}*b*d=0.25*\frac{\sqrt{24}}{420}*800*392=914.48$ mm².

So, As = 426.42 mm² < As (min) = 1045.3 mm²

As ø 16 =201 mm²

$N_{req}=\frac{AS_{req}}{AS\#\ BARS}=\frac{1045.3}{201}=5.23 basrs$

Select 6 ø 16 AS = 1206 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * b

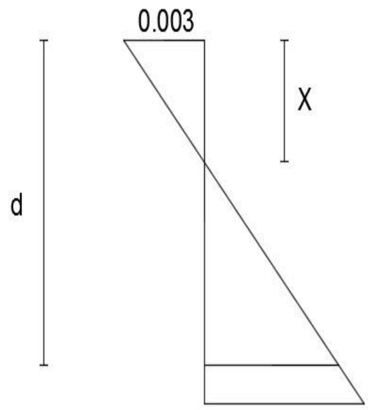
1206*420=0.85*24*a*800

a= 31.036 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 31.036/ 0.85 = 36.514 mm



From Strain Diagram:

$$\frac{\mathbf{0.003}}{\mathbf{36.514}} = \frac{\mathbf{0.003+\varepsilon s}}{\mathbf{392}}$$

ε_s=0.029>0.005

So,

Ø = 0.9 … (OK)

✓ Design of Positive Moment Mu = 206. 7KN.m

Assume bar diameter ø 16 for main positive reinforcement

d =450-40-10-16/2=392mm

Kn= $\frac{Mu/\ Ø}{b*d^2} = \frac{206.7*10^6/\ 0.9}{800*392^2} = 1.87$ Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*1.87*20.6}{420}}\right) = 0.00467$$

As (req) = ρ * b *d = 0.00467* 800 * 392 = 1467 mm².

Check As(min):

As (min)= $\frac{1.4}{fy} * b * d = \frac{1.4}{420} * 800 * 392 = 1045.3$ mm².« controll

Or

As (min)=0.25 $* \frac{\sqrt{fć}}{fy} * b * d = 0.25 * \frac{\sqrt{24}}{420} * 800 * 392 = 914.48$ mm².

So, As = 1467 mm² > As (min) = 1045.3 mm²

As ø 16 =201 mm²

$N_{req} = \frac{AS_{req}}{AS\# \ BARS} = \frac{1467}{201} = 7.3 basrs$

Select 8ø 16 AS = 1608 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * b

1608*420=0.85*24*a*800

a= 41.38 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 41.38/ 0.85 = 48.68 mm

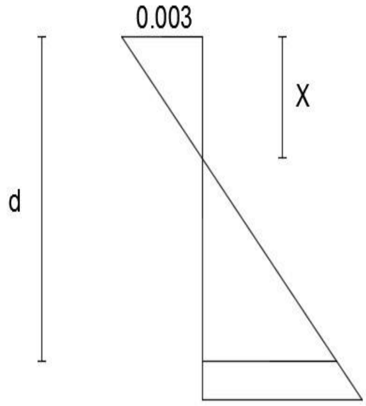
From Strain Diagram:

$$\frac{0.003}{48.68}=\frac{0.003+\varepsilon s}{392}$$

ε_s=0.021>0.005

So,

Ø = 0.9 … (OK)



✓ **Design of Negative Moment Mu = - 269.4 KN.m**

Assume bar diameter ø 16 for main positive reinforcement

d =450-40-10-16/2=392mm

Kn = $\frac{Mu/\text{Ø}}{b*d^2}=\frac{269.4*10^6/0.9}{800*392^2}=2.43$ MPa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho=\frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right)=\frac{1}{20.6}\left(1-\sqrt{1-\frac{2*2.43*20.6}{420}}\right)=0.0062$$

As (req) = ρ * b *d = 0.0062* 800 * 392 = 1944.32mm².

Check As(min):

As (min)=$\frac{1.4}{fy}*b*d=\frac{1.4}{420}*800*392=1045.3$ mm².« controll

Or

As (min)=0.25 $* \frac{\sqrt{fć}}{fy} * b * d = 0.25 * \frac{\sqrt{24}}{420} * 800 * 392 = 914.48$ mm².

So, As = 1944.32 mm² > As (min) = 1045.3 mm²

As ø 16 =201 mm²

$N_{req} = \frac{AS_{req}}{AS\# \ BARS} = \frac{1944.32}{201} = 9.6 \ basrs$

Select 10 ø 16 AS = 2010 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc’ * a * b

2010*420=0.85*24*a*800

a= 51.73 mm.

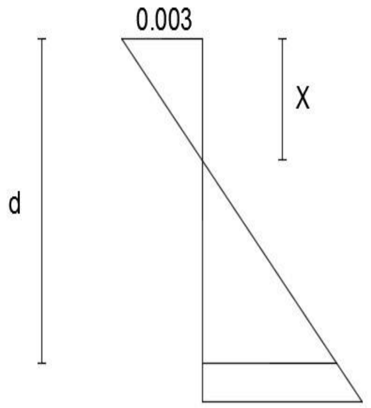
Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 51.73/ 0.85 = 60.85mm

From Strain Diagram:

$\frac{\mathbf{0.003}}{\mathbf{60.85}} = \frac{\mathbf{0.003+\varepsilon s}}{\mathbf{392}}$



ε_s=0.016>0.005

So,

Ø = 0.9 … (OK)

- ✓ **Design of Negative Moment Mu = 176KN.m**

Assume bar diameter ø 16 for main positive reinforcement d =450-40-10-16/2=392mm

Kn = $\frac{Mu/\emptyset}{b*d^2}$ =$\frac{176*10^6/0.9}{800*392^2}$ $= 1.59$ MPa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*1.59*20.6}{420}}\right) = 0.0049$$

As (req) = ρ * b *d = 0.0049* 800 * 392 = 1536.64mm².

Check As(min):

As (min)=$\frac{1.4}{fy} * b * d = \frac{1.4}{420} * 800 * 392 = 1045.3$ mm².« controll

Or

As (min)=0.25 $* \frac{\sqrt{fć}}{fy} * b * d = 0.25 * \frac{\sqrt{24}}{420} * 800 * 392 = 914.48$ mm².

So, As = 1536.64 mm² > As (min) = 1045.3 mm²

As ø 16 =201 mm²

$N_{req} = \frac{AS_{req}}{AS\#\ BARS} = \frac{1536.64}{201} = 7.6\ basrs$

Select 8 ø 16 AS = 1608 mm²

Check Strain:

T = C

As * Fy = 0.85 * Fc’ * a * b

1608*420=0.85*24*a*800

a= 41.38 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 41.38/ 0.85 = 48.68mm

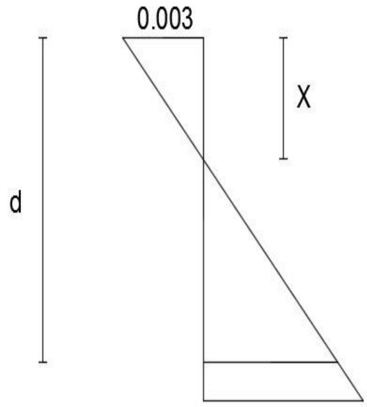
From Strain Diagram:

$$\frac{0.003}{48.68} = \frac{0.003+\varepsilon s}{392}$$

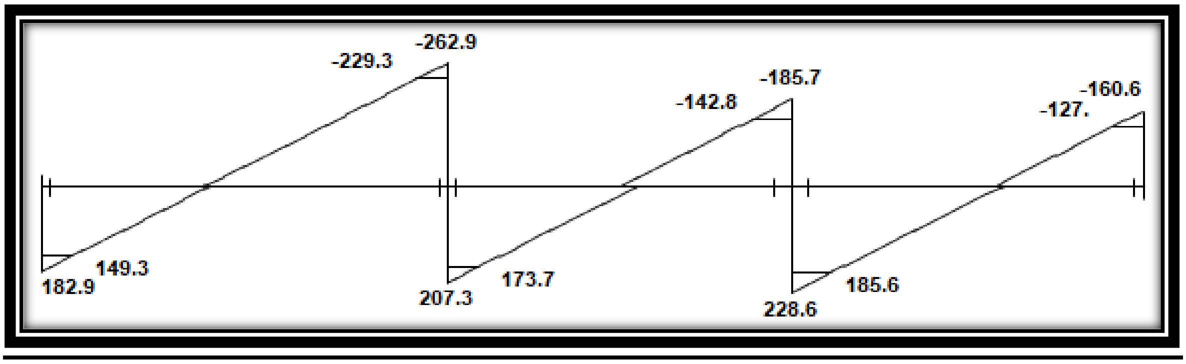
ε_s=0.021>0.005

So,

Ø = 0.9 … (OK)



Design of shear for Beam



Picture 52: Shear Envelope of Beam

Vu = 229.3 KN

d = 392 KN

Ø * Vc =0.75*$\frac{1}{6} * \sqrt{fć}$ *b*d=0.75* $\frac{1}{6} * \sqrt{24}$ *800*392=192KN < Vu =229.3 KN

So, we need shear reinforcement

CASE 3:

Ø * Vc < Vu ≤ Ø * Vc + Ø * Vs_{min}

Ø * Vc = 0.75*$\frac{1}{6} * \sqrt{fć}$ *b*d=0.75* $\frac{1}{6} * \sqrt{24}$ *800*392 = 192KN

Ø *Vs_{min} = 0.75*$\frac{1}{16} * \sqrt{fć}$ *b*d=0.75* $\frac{1}{16} * \sqrt{24}$ *800*392 = 72.01 KN

OR

$\text{Ø} *Vs_{min}$= 0.75*$\frac{1}{3}$ *b*d=0.75* $\frac{1}{3}$ *800*392=78.4 KN… CONTROL

Ø * Vc + Ø *Vs_{min}= 192KN+78.4 KN=270.4 KN >Vu =229.3KN

Ø *VS = Ø *Vs_{min} =78.4

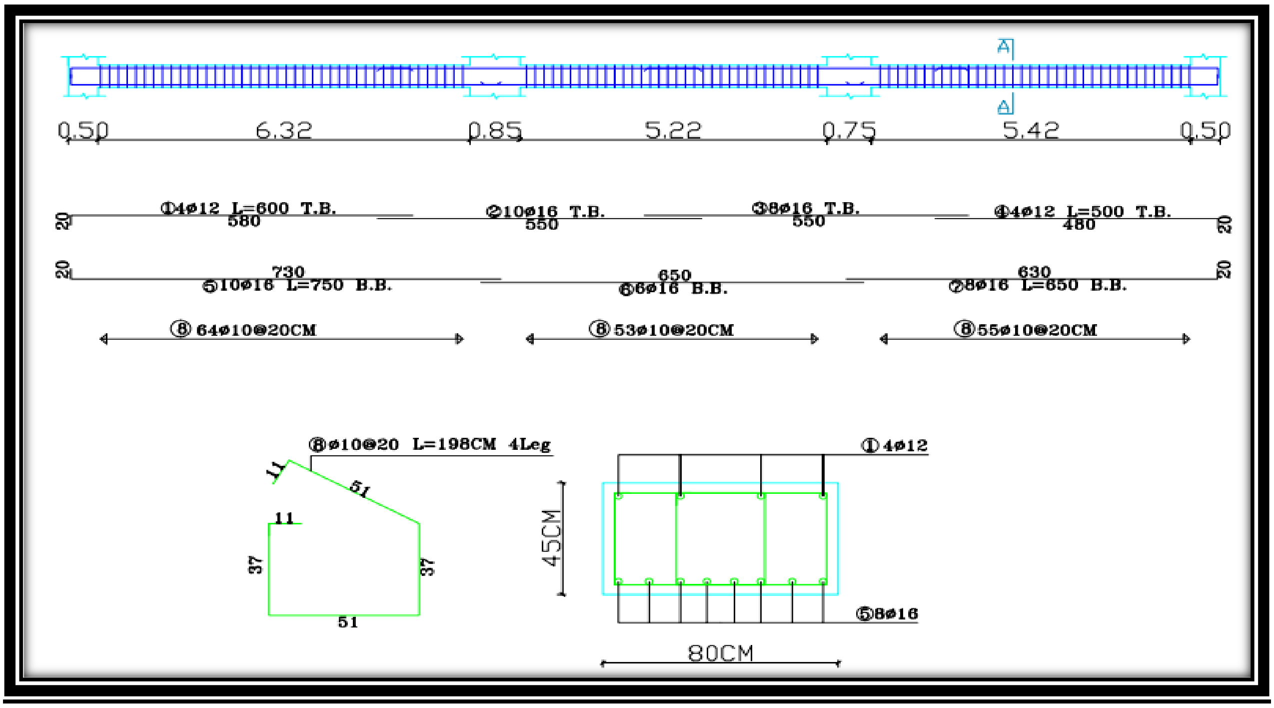
Av=# of legs*As= 4*$\frac{\pi*10^2}{4}$ =314mm^2

$S_{req}=\frac{Av*fy*d*\text{Ø}}{Vs*\text{Ø}}=\frac{314*420*392*0.75}{78.4*10^3}=494.55\ mm$

$S_{req}\leq\frac{d}{2}=\frac{392}{2}=196mm$

$\leq 600mm$

Use 4 legs, Ø10@200*mm*



Picture 53: Reinforcement of Beam

4.8 Design of Column C10

$f\acute{c} = 24\ Mpa$ **fy = 420 Mpa**

Dead =5565.64 KN **Live =1912.657 KN**

Solution:

Check Slenderness:

$$\frac{\boldsymbol{Klu}}{\boldsymbol{r}} \leq \mathbf{34 - 12}\ (\frac{\boldsymbol{m1}}{\boldsymbol{m2}}) \leq \mathbf{40}$$

About x & y axis
B = 75cm = h
K = 1 for braced
Lu = 3.9 m

$$\frac{1 * 3.9}{0.3 * 0.75} = 17.33 \leq 22\ \leq 40$$

Its Short Column in Both Direction

Pu = 1.2*Dead +1.6*Live
= 1.2*5565.64 +1.6*1912.657 =9470KN

Pu =$\emptyset * \mathbf{0.8}\left\{\mathbf{0.85} * \ \boldsymbol{f\acute{c}}\ (\boldsymbol{Ag} - \boldsymbol{Ast}) + \boldsymbol{Ast} * \boldsymbol{fy}\right\}$

$\emptyset = 0.65\ for\ tied\ Column$

Ag = 750 *750 =562500 mm^4

$9740 * 10^3\ = 0.65 * 0.8\left\{0.85 * 24\ (562500 - Ast) + Ast * 420\right\}$

Ast = $\frac{9740 * 10^3 - 5967000}{207.79}$ = 18157.77mm^2

Select 24 Ø 32 As = 19224 mm^2 As longitudinal bars

Design for Ties:

Use Ø 10

1. **48*** d_s = 48*10 = 480 mm
2. **16***d_b = 16 *32 = 512 mm
3. **The least dimension of the column** = 750 mm

Use Ø 20@ 20cm as stirrups bars

Check code required

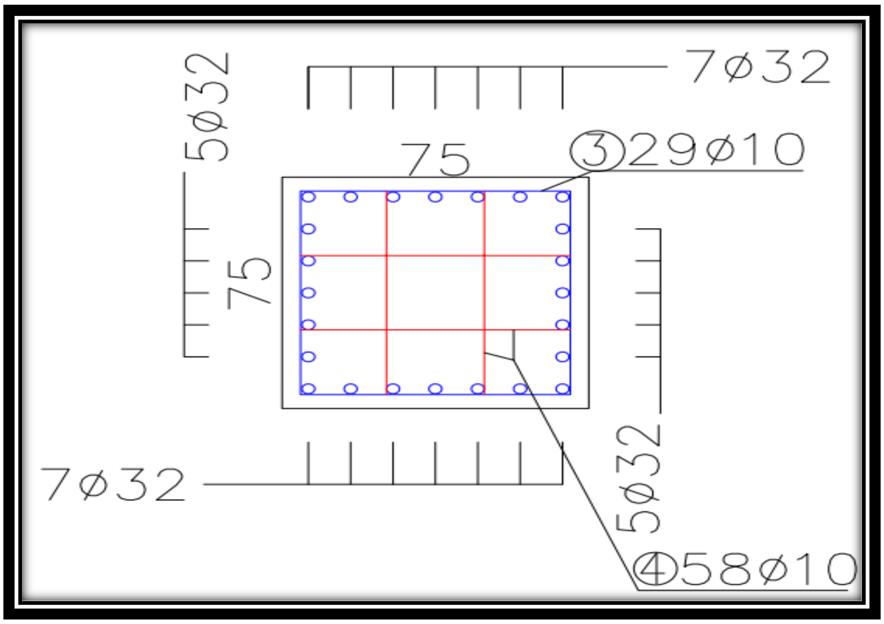
1. Clear spacing between longitudinal bars:

Clear spacing = $\frac{750-40*2-10*2-7*32}{6}$ = 71mm > 40mm ……… **(OK)**

2. Gross reinforcement ratio:

$$0.01 \leq \rho \leq 0.08$$

$\rho = \frac{19224}{562500} = 0.034 > 0.01$ …………..**(OK)**



Picture 54: Reinforcement of column

4.9 Design of Footing F10

Dead =5565.64 KN

Live =1912.657 KN

Fy=420 Mpa

$f\acute{c} = 24\ Mpa$

$\gamma_{soil} = 17\ KN/m^3$

$\gamma_{RC} = 25\ KN/m^3$

SOLUTION :

Design of Bearing Pressure:

Assume h=115 cm

FOR ($1m^2$) Under the footing:

Live load = $5\ KN/m^2$
Weight of soil = 17*0.6 =10.2 KN/m^2
Weight of Footing =25*1.15 =28.75 KN/m^2

Net allowable bearing pressure ($\sigma_{b\ allow}$) =500-5-10.2-28.75 =456.05 KN/m^2

$$\sigma_{bu} = \frac{PU}{A} \leq 1.4 * \sigma_{b\ allow\ net}$$

PU = 1.2*Dead+1.6*Live = 1.2*5565.64+1.6*1912.657 = 9740 KN

$$\frac{9740}{a * a} = 1.4 * 456.05$$

a =3.90 m → **a=4.00m**

Bearing Pressure (σ_{bu}) = $\frac{PU}{A} = \frac{9740}{4*4}$ = 608.75 KN/m^2

Design of one-way shear:

Ø *vc =0.75 *$\frac{1}{6} * \sqrt{fć}$ *b*d

d = h- cover - Ø = 1150 -75 -20 = 1055 mm

vu = σ_{bu} *0.75*b

=608.75*0.75*4 = 1387.95 KN

Ø *vc = 0.75 *$\frac{1}{6} * \sqrt{24}$ *4000*1055

= 2584.211 KN > VU = 1387.95 ….….(OK)

Design of Two-way shear:

d = 1055 mm

bo =4*(1055+750) =7220 mm

β_c =1.0

α_s= 40

Ø *VC ≥ Vu

VU= Pu - F_{RB}

= 9740 – 608.75*1.805*1.805

= 7756.67 KN

Ø *VC = 0.75* (2+ $\frac{4}{1}$)* $\frac{\sqrt{24}}{12}$ *7220* 1055 =13993.506 KN

Ø *VC = 0.75 *($\frac{40*1055}{7220}$)* $\frac{\sqrt{24}}{12}$ *7220*1055 = 13631.716 KN

Ø *VC = 0.75* $\frac{4}{12}$ *$\sqrt{24}$ *7220 * 1055 = 9329 KN ……………... **Controlled**

Ø *VC = 9329 KN > VU = 7756.67 KN ………. (OK)

h=1.15 m …………………….(OK)

Design of reinforcement (Bending Moment):

Mu: Factored internal resultant moment at the critical section at the face of column.

Mu = 608.75*4*1.625*0.8125 =3214.96 KN.m

Design of rectangular section

$$\frac{b}{d} = \frac{4000}{1055} = 3.8$$

Kn = $\frac{Mu/\, Ø}{b*d^2} = \frac{3214.96*10^6/\ 0.9}{4000*1055^2} = 0.80$ MPa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.80*20.6}{420}}\right) = 0.002$$

As (req) = ρ * b *d = 0.002× 400× 105.5 = 84.4 $cm^2/total(a)$

Check for minimum (As):

As (min) for slabs and footings is As (min) for shrinkage and temperature $Asmin$ **= 0.0018 × b × h** = 0.0018 × 400 × 115 = 82.8 cm^2

$Asreq$ **= 84.4** cm^2 > $Asmin$ **= 82.8** cm^2 → $OK\#$

Select 34Ø18 with As =34 × 2. 54= 86.5 cm^2 in both direction

- Design of Connection between column and footing:

Design of bearing pressure at section of column (10)

$\boldsymbol{\emptyset \times Pnb = 0.65 \times 0.85 \times fc' \times A1 \geq Pu}$

$\emptyset \times Pnb = 0.65 \times 0.85 \times 24 \times 750 \times 750 = 7458 KN < Pu = 9740$ KN

Load transfer between column and footing cannot be done through concrete alone!

→ Dowels are required to transfer the load

. Design of Dowels

Difference between $(\emptyset \times Pn)$ and (Pu) will be carried from dowels.

$\boldsymbol{As \times Fy ---- Steel\ compression\ force}$

$\boldsymbol{\emptyset \times Pn \geq Pu}$

$Pbn = \frac{pu}{\emptyset} = \frac{9740}{0.65} = 14984.6$ KN

$Pbn = \frac{7458}{0.65} = 11473.8$ KN

$AS_{req} = \frac{\Delta p}{fy} = \frac{14984.6 - 11473.8}{420} = 836\ mm^2$

$\boldsymbol{Asmin = 0.005 \times A1} = 0.005 \times 75 \times 75 = 28.125\ cm^2$

Select 4 Ø32 with As = 4× 8. 04 = 32.16 cm^2 > Asmin = 28.125 cm^2

Design of Compression lap splice between steel of column and dowels (Lsc)

$\boldsymbol{Lscreq = 0.071 \times fy \times db} = 0.071 \times 420 \times 32 = 954.24\ mm$

Select Lsc = 1m = 1000mm > Lscreq = 954.24 mm

Design of compression development length (Ldc)

$$Ldc = 0.24 \times \frac{fy}{\sqrt{fc}} \times db = 0.24 \times \frac{420}{\sqrt{24}} \times 32 = 658.422 \text{ mm}$$

$$Ldc = 658.422 \text{ mm} > 0.043 \times fy \times db = 0.043 \times 420 \times 32 = 577.92 \text{ mm}$$

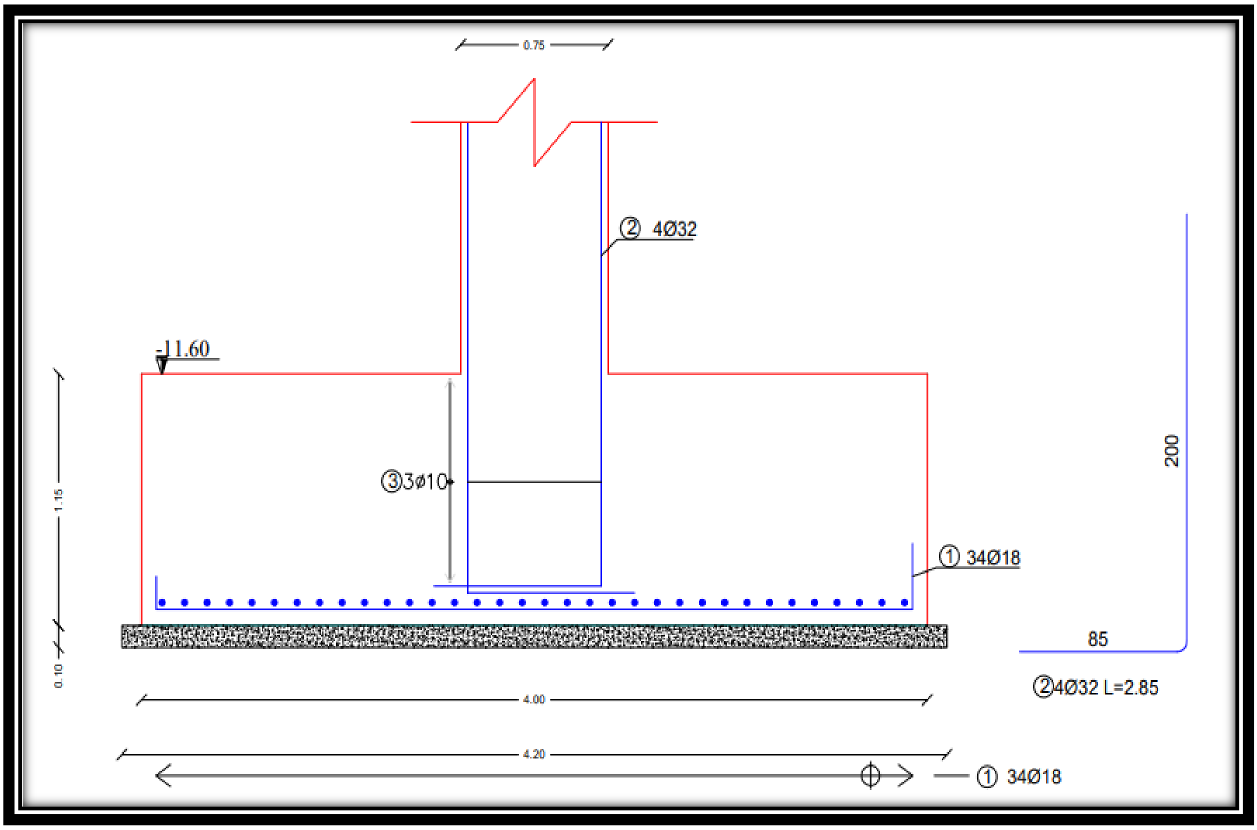
$$Available\ Ldc = 1150 - 75 - 32 - 32 = 1011mm > Ldc = 658.422 \text{ mm}$$

Design of tension development length of footings reinforcement:

Category (A):

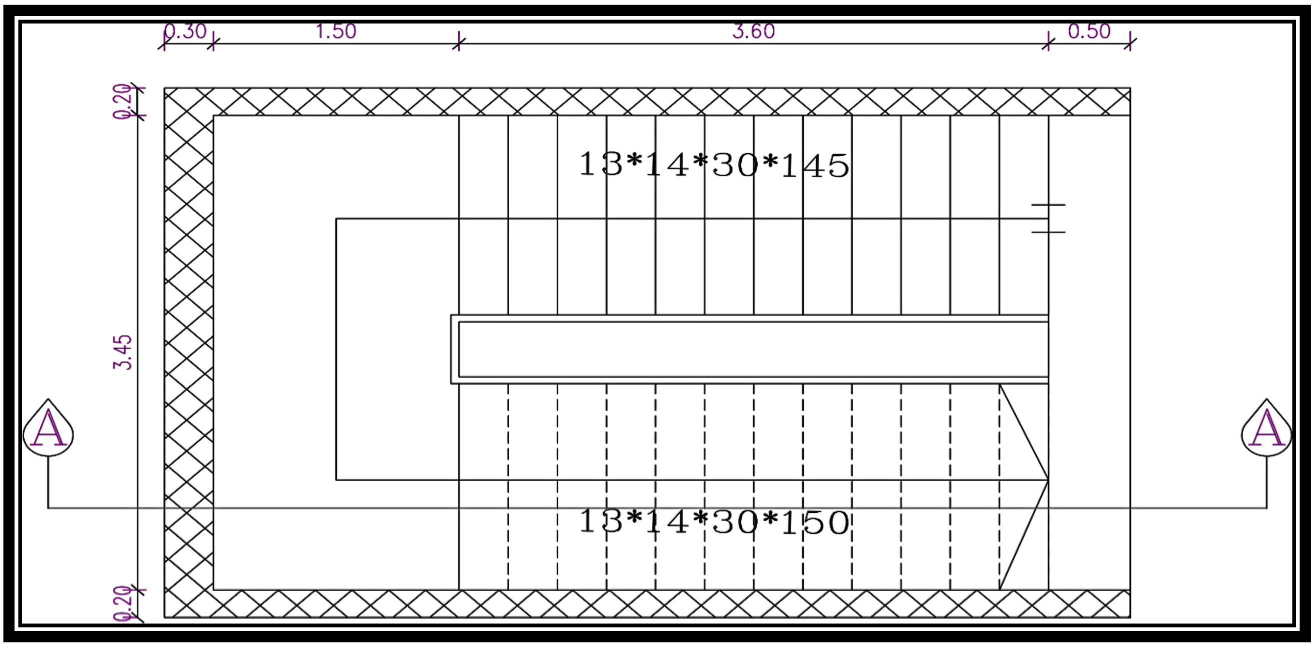
$$Ldt = \frac{12}{25} * \frac{fy}{\sqrt{fc}} * \frac{\varphi_t * \varphi_e}{\lambda} = \frac{12*420*1*1}{25*\sqrt{24*1}} * 32 = 1316.8 \text{ mm}$$

$$Ldt{-}available = 1625 - 75 = 1550mm > Ldt{-}req = 1316.8 \text{ mm} --- OK\#$$



Picture 55: Reinforcement of Footing

4.10 Design of stair



Picture 56: Plan of stair

Design of flight:

h≥ min h

$h= \frac{l}{20} = \frac{360}{20} = 18$ cm

Select h= 20 cm

angle α :

$\tan\alpha = \frac{14}{30}$ ……….. **α =25°**

Dead load of flight:

Flight = 0.2*25*1*1/cos25 = 5.516 KN/m
Plaster = 0.03*22*1*1/cos 25 = 0.728 KN/m

Horizontal mortar = 0.03*22*1 = 0.7 KN/m
Vertical mortar = 0.03*22*0.14/0.3 = 0.308KN/m
Horizontal Tiles = 0.04*23*1*33/30 = 1KN/m
Vertical Tiles = 0.03*23*0.14/0.3 = 0.322 KN/m
Triangle = 0.5*0.14*25 = 1.75 KN/m

Sum = 10.324 KN/m

Dead load = 10.324 KN/m

Live load = 5 KN/m

qu=1.2 dead load +1.6 live load = 1.2*10.324 +1.6*5 = 20.38 KN/m

AU = (qu/2) *3.60 = (20.38/2) *3.60 = 36.684 KN

Max vu =36.684*cos 25
= 33.24 KN

Mu = 36.684*2.2 -20.38*1.8*0.9
= 47.68 KN.m

d = 200-(20+0.5*12) = 174 mm

Ø *VC =0.75 * $\frac{1}{6} * \sqrt{f\acute{c}}$ ***b*d =106.5 KN > Max Vu = 33.24 KN**

MU =47.68 KN.m
d = 174 mm

Kn = $\frac{Mu/\,Ø}{b*d^2} = \frac{47.68*10^6/\,0.9}{1000*174^2} = 1.74$ MPa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*1.74*20.6}{420}}\right) = 0.0036$$

As (req) = ρ * b *d = 0.0036*1000 * 174 = 626.4 mm^2

Asmin =360 mm^2

Select Ø 12 /18 cm   AS=628.31 mm^2

0.85* fć *a*b =AS* fy
0.85*24*a*1000 = 628.31 *420
a = 12.9
x =15.2 $\varepsilon s = 0.003 * \frac{174}{15.2}$
$= 0.034 > 0.005$ ………… **Ø =0.9 (OK)**

Design of Landing

h min = L/20 =3.60/20 =18 cm
Select h =20cm

Load :

Tiles = 0.92 KN/m
Mortar =0.44 KN/m
Sand =1.12 KN/m
Slab = 5 KN/m
Plaster = 0.66 KN/m

Sum = 8.14 KN/m

VU =31.98-17.768*0.324 =26.22 KN

MU =(17.768 *3.6*3.6)/8 =28.78 KN.m

Ø *VC = 106.5 > 26.22 …………… {NO Shear Reinforcement}

MU < 47.68 KN.m

Select Ø 12 /20cm

Slab 2

qu =17.768 +36.684 = 54.452 KN

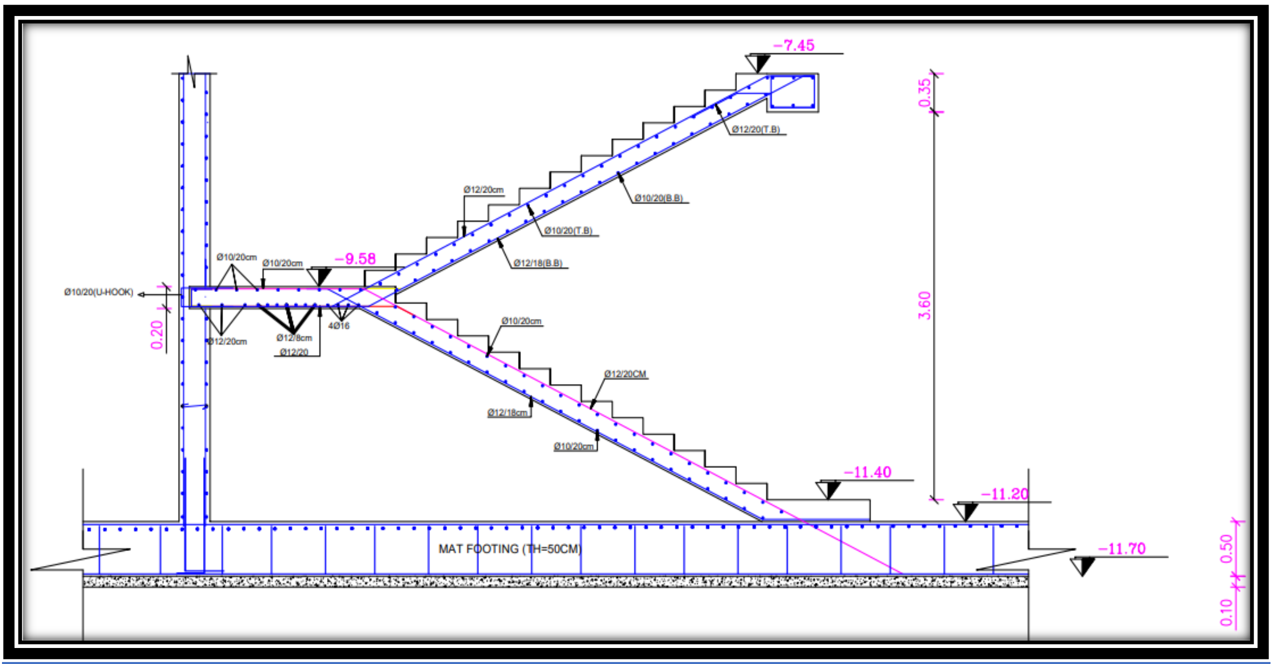
VU = 98.0136 – 54.452 (0.324) = 80.37 KN

Ø*VC = 387KN > VU =80.37 KN

MU= (54.452 *3.6*3.6)/8 =88.2 KN.m

KN= 3.2 Mpa
m= 20.6
ρ=0.008
Asreq =1392 mm²

Select Ø 12 /8 cm AS= 1413.7 mm²



Picture 57: Reinforcement of stair

4.11 Design of Shear wall

Fć =24 Mpa **Fy = 420 Mpa** **h = b = 30 cm**

Lw = 3.10 m **Hw =31.6 m**

Design of horizontal Reinforcement:

Fx =Vu = 950 KN

Critical section of shear the smaller of:

$$\frac{lw}{2} = \frac{5.35}{2} = 2.675 \text{ m} \ldots\ldots\ldots\ldots \text{ Controlled}$$

$$\frac{hw}{2} = \frac{31.6}{2} = 15.8 \text{ m}$$

Story Hight (HW) = 3.6 m

d = 0.8 *Lw = 0.8* 3.10 = 2.48 m

shear strength of concrete vc

$$Vc = \frac{1}{6} * \sqrt{Fć} * b * d = \frac{1}{6} * \sqrt{24} * 300 * 2480 = 607.47 \text{ KN} \ldots\ldots\ldots\ldots (\textbf{Controlled})$$

$$Vc = \frac{\sqrt{Fć} * b * d}{4} + \frac{Nu * d}{4 * lw} = \frac{\sqrt{24} * 300 * 2480}{4} + \frac{0 * 2480}{4 * 3100} = 911.210 \text{ KN}$$

$$Vc = \left\{ \frac{\sqrt{Fć}}{2} + \frac{lw\left(\sqrt{Fć} + \frac{2NU}{Lw * h}\right)}{\frac{mu1}{vu} - \frac{lw}{2}} \right\} * \frac{h * d}{10}$$

$$= \frac{\sqrt{24}}{2} + \frac{3.10\left(\sqrt{24} + \frac{2 * 0}{3100 * 300}\right)}{\frac{3100}{950} - \frac{3.10}{2}} \Big\} * \frac{300 * 2480}{10} = 841.78 \text{ KN}$$

Vc = 607.47 KN

($\emptyset * Vc$) < VU ………………...Horizontal Reinforcement is required

Ø* Vc + Ø*Vs = Vu

Vs = Vu/Ø - Vc = 950/0.75 – 607.547 = 659.11 kN

$$\frac{\mathbf{Avh}}{\boldsymbol{s}} = \frac{\mathbf{Vs}}{\boldsymbol{fy} * \boldsymbol{d}}$$

$$\frac{\text{Avh}}{s} = \frac{659.11 * 1000}{420 * 2480} = 0.63$$

$$\frac{\mathbf{Avh}}{\boldsymbol{s}} = \mathbf{0.0025} * \mathbf{h} = 0.0025 * 300 = 0.75$$

$\frac{\text{Avh}}{s} = 0.75$ **is controlled**

Smax = Lw/5 = 3100/5= 620 mm<u>**………. controlled**</u>

= **3*h** = 3*300 = 900 mm

<u>**Select Ø 12**</u>

Avh = 2 legs * π/4 * 12^2 = 226 mm^2
Avh /s = 0.75

Sreq = Avh/0.75 = 226/0.75 = 301 mm
select S= 300 mm < Smax = 620mm **(Ok**)

<u>**Select Ø 10**</u>

Avh = 2 legs * π/4 * 10^2 =157 mm^2
Avh /s = 0.75

Sreq = Avh/0.75 = 157/0.75 = 209 mm
select S= 200 mm < Smax = 620mm (**Ok**)

Design of uniform distributed vertical reinforcement:

Avv = 0.0025 + 0.5 (2.5 – hw/Lw) *(Avh/(S horizontal*h) -0.0025)* h *S

Avv/s =(0.0025 +0.5 (2.5 – 31.6/3.10) * (2*79 /(200*300) – 0.0025)) * 300
= 0.75

Select Ø10, 2 layers

Avv = 2*79 =157 mm^2

157/S = 0.75

S req = 117.75 mm

select S = 150 mm

Smax = Lw/5 = 3100/5= 620 mm

= 3*h = 3*300 = 900 mm

= 620 mm **controlled**

S = 150 mm < 620 mm **………Ok**

Design of Bending Moment:

Mu = 3100 kNm

Mu = Muv + Mu boundary

Asv = 2*79 * 3100/300 = 1632.66 mm^2

$$\frac{z}{Lw} = \frac{1}{2 + \frac{0.85 * \beta * fc' * Lw * h}{Asv * fy}} = \frac{1}{2 + \frac{0.85 * 0.85 * 24 * 3100 * 300}{1632.66 * 420}}$$

$$= 0.039$$

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

= 0.9 * (0.5 *1632.66*420*3100*(1-0.039/2)
= 937.922 KN.m< Mu = 3100 KN.m

Mub = Mu – Muv = 3100-937.922 = 2162.078 Kn

X ≥ (Lw /(600 *Δu/hw)) = 3100/(600*0.009) = 574.07mm

LB ≥ X/2 = 574.07 /2 = 287.03 mm

≥ x-0.1*Lw = 574.07 - 0.1*3100 = 264.07 mm

Select LB=30cm

A_{SB} = MuB*Ø /(fy*(Lw-LB))
= 2162.078 /0.9 / (420(3100-300)
= 1988.7 mm^2

Select 10Ø16 with As =2010.61 mm^2

Chapter 5
Outcomes and Recommendations

- **5.1 Introduction**
- **5.2 Outcomes**
- **5. 3 Recommendations**
- **5. 4 Reference**

5.1 Introduction

In this project, architectural plans were obtained that lack a lot of things. After studying all the requirements, architectural plans and comprehensive structural plans for the college proposed to be built in the city of Hebron were prepared.

Some construction plans were prepared in a detailed, accurate and clear manner to facilitate the construction process. This report provides an explanation of all the architectural and structural design steps of the building

5.2 Outcomes

- Every student in the work team will be able to design the structural elements manually so that they have sufficient experience and knowledge in using computerized design programs.

- Among the factors that we must take are the natural factors surrounding the building such as wind, rain, snow, the nature of the site and the impact of natural forces on it, such as earthquakes.

- Through what we have done from the design of the building, we must take a comprehensive view of the building to link the various structural elements and then divide these elements to design them individually and know how to design taking into account the surrounding circumstances.

- In this project, the one-way ribbed system was used and two-way ribbed slab in the building, drops beams were used due to the nature and shape of the building.

Solid Slab has also been used in the staircase slabs and cars' parking because they are more effective than nerve nodes in carrying concentrated loads.

– The computer programmers that used are:

A – Microsoft office programs

B – AutoCAD program

C – Atir program

5. 3 Recommendations

This project worked to clarify and expand our understanding of the nature of construction projects, including the details, designs, architectural and construction analyzes.

From this experience we want to present a set of important recommendations:

- To obtain comprehensive information about the nature of the site, its soil and its durability, through an examination and a report specific to that region.

- The architectural design should be chosen and then all architectural and Construction plans are coordinated and prepared.

- At this stage, the appropriate structural system must be chosen in the construction process, such as a structural system or a system of load-bearing walls of reinforced concrete and stone faces.

- A complete agreement and coordination must be found between the civil engineer and the architectural designer. The structural engineer must design the structural elements according to the plans. He must design a structural system that is resistant to vertical loads and horizontal forces caused by wind and earthquake loads.

- The electrical and mechanical design of the project must be completed before starting in a worksite to make any possible modifications to the project from a structural point.

5. 4 Reference

1 – ACI – 318 16 ‘’ American Code ‘’

2 - Jordan Code

3 – Reinforced concrete I, II ‘’ DR. Nasser Abboshi’’ & Dr. Maher Amro

4- Wikipedia