Chapter I

Project Introduction

Project Introduction

1.1 Introduction:

Building or dwelling is the most important necessity in life throughout ages. As time passes, the presence of different buildings for various aspects of human life becomes urgent. We need buildings for worship, as well as government buildings like hospitals, school, courts and so on clubs, libraries, commercial and residential buildings are very important nowadays.

However human evolution and the continuous industrial openness were necessary to keep up with events to meet the needs of various categories of people and their jobs. Here comes the role of the engineer who puts his ideas and solutions in order to proceed to the furtherance of human revolution.

As the Engineer is designing and creating a safe haven for the man return to his home after a long day fatigued and tired, the same of people gather under one roof in a musical event here and the last athlete out there, all the shortcut Engineer is one of the shows or at least trying to beauty buried appears behind the face of nature.

The study in the center of this project is to undertake a structural design public library.

1.2 Search Problem:

The problem with this project in the analysis and structural design of all the components of the library building structural elements, which was adopted to be an arena for this search, and in this area will be each element of the structural elements such as tiles, nerves, columns, bridges and foundation analysis, determining the loads located on them, and then determine the dimensions and design reinforcement it necessary, taking into account the safety factor of origin, and then will work shop drawings for structural elements that have been designed, to take out of this project into the proposal into effect.

Reasons for choosing the project:

The importance of choosing the project to several things, the most important skill acquisition in constructional design elements in buildings. In addition to increasing knowledge of the construction of the systems in place in our country, as well as the acquisition of scientific knowledge and the process followed in the design and implementation of construction projects that lie ahead after graduation in the labor market.

One of the things that made us do this search is to present this project to the Civil and Architectural Engineering Department at the Faculty of Engineering and Technology in Palestine Polytechnic University to meet the terms of graduation and get a bachelor's degree in civil engineering specialty engineering buildings.

Personal reasons: -

1- The desire of the project team that the project be structurally.

2. Desire to acquire the structural design skill by linking theoretical aspects that have been gained from the courses studied, and apply it effectively in this project and the contents of various structural elements, the design of these elements to fit with loads located them, taking into account the provision of workers durability and economy .

1.4 Project Objectives:

We hope that after completion of this research we have come to the following objectives:

1) The ability to choose the right system for various construction projects and distribution of elements on the construction plans, taking into account the preservation of architectural character.

2) The ability to design the various structural elements.

3) Application and linking information that have been studied in different courses.

4) Mastering in the use of structural design software and compare it with the manual solution.

1.5 Material and Resource:

1. Microsoft Word.

2. American code for structural designs (ACI-318-08M).

3. Use analysis software and structural design such as Atir, Safe, Etabs and others.

1.6 Project chapters:

Chapter I: Project Introduction.

Chapter II: Architectural Description.

Chapter III: Structural Description.

Chapter IV: Structural Analysis & Design.

1.7 Domain of project:

1) Preparation of a full architectural plan, validating architectural aspects and compatibility with the objectives of the project and its services.

2) Study structural components of the public library and the most appropriate mechanism for the distribution of these elements such as columns, bridges and nerves are not collide with the subject of architectural design and achieve the economic side and the safety factor.

3) Analysis of structural elements and loads acting on them.

4) The design of structural elements based on the results of the analysis.

5) Design by different design programs.

6) The completion of shop drawings for structural elements that are designed to get the project in its final form and integrated executable.

1.8 project site:

When we begin to design any project, it must take a number of things into consideration to get end a good project that's meets all the needs which it was established, and also does not suffer from any other problems, and thus we get the inconsistency between the proposed design of the site and the components of that site affecting it. Therefore, it must give a good idea of the elements of the site such as the nature of the site, proposed building and its relation with the streets, and also it must take into account in the construction of the building the movement of the sun from sunrise to sunset and the nature of the wind and its direction, Add to that the nature of the surrounding buildings origin itself and the extent of height.

This proposed project is located in an area (Wade AL-Hareyah) in Hebron And to the side of the B+ building, and must say that the infrastructure of roads, electricity and communications link to that site and provide what it needs with the need for some development. It should be noted here that the project was selected and previewed before starting the architectural design, it has been achieved the actual function of the building and all the aesthetic factors also, the building has also been directed to meet the purposes of ventilation and lighting.

1.9 Time schedule: -

Table (1-1) shows the timeline for the stages of work on the project, according to the proposed steps during the first semester:

Table(1-1) Timeline for the Stages of work on the project.

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Week / Task
															■	**Project selection**
														■		**Study The Site**
													■			**Collect Information**
											■	■				**دراسة المبنى معماريا**
										■	■					**دراسة المبنى انشائيا**
									■							**اعداد مقدمة المشروع**
								■								**عرض مقدمة المشروع**
						■	■	■								**Structural analysis**
				■	■											**Structural design**
			■	■												**اعداد مخططات المشروع**
	■	■	■													**Writing project**
■																**Project View**

Chapter 2

Architectural Description

Architectural Description

2-1 Introduction:

Architecture is one of the most prominent engineering sciences, which is not the result of this era, it is since God created man who unleashed his talents and his thoughts, skip this talent from the life of the caves to the best of welfare, where he took advantage of what God has given the beauty of this nature.

Architecture has become an art and talent and ideas, it derives its fuel from what God gave for the architect beautiful talents, If each art or knowledge has controls and limits, then the architecture is not subject to any limit or restriction, they are oscillating between imagination and reality and the result may be micro simple buildings and candor raises us some curiosity.

The simplicity of the building is not evidence of the simplicity of architectural work, but that the building in spite of simplicity has in store for us the beauty, and architecture in the interior of its parts, that making it superior to many other buildings. the building is no matter what its job would have made architectural conditions, completely when mixed between the real beauty in the elevations of the building form and function to be performed, by that building has succeeded architecturally because the architectural concept is not limited to the shape as some think; but also achieves the function.

The building may seem simple from the outside, like a fragmented into several large pieces without a sense the communication between these pieces, but in fact connected and threaded across multiple spaces and bridges.

The design of any structure or building process conducted through several stages until it is completely done begin first phase of architectural design ,where they are at this stage have to determine the shape of origin and taken into account to achieve the different functions and requirements for this building .

After the completion of the architectural design phase and out final form, structural design process which aims to identify the dimensions of structural elements and characteristics begin, depending on various loads located and which are transported through these items to the foundations and then to the soil.

The idea of the design of the library building of the University of Palestine Polytechnic, was the result of the urgent need for a special building for readers and writers because of their studies need large privacy and the need to focus and calm to study and comfortable environment, all of that and other reasons led to the actual thinking in the design of this new building Polytechnic's where they are most needed.

2-2 An overview of the project:

The idea of the project is to create a "public library" building with all the necessary facilities and departments, and the building has a very beautiful architectural form,In addition to maintain the performance of the job, along with the beautiful architectural form.

We got the architectural plans for the project from "Civil and Architectural Engineering Department" in the "Palestine Polytechnic University", so that we begin to structural design work after an analytical and detailed study of those architectural plans, which is prepared by the student (Mohammed al atrash), where the project consists of three floors, where the functional services appropriately vary with the need of the required design.

2-3 project site:

When we begin to design any project, it must take a number of things into consideration to get end a good project that's meets all the needs which it was established, and also does not suffer from any other problems, and thus we get the inconsistency between the proposed design of the site and the components of that site affecting it. Therefore, it must give a good idea of the elements of the site such as the nature of the site, proposed building and its relation with the streets, and also it must take into account in the construction of the building the movement of the sun from sunrise to sunset and the nature of the wind and its direction, Add to that the nature of the surrounding buildings origin itself and the extent of height.

This proposed project is located in an area (Wade AL-Hareyah) in Hebron, and must say that the infrastructure roads, electricity and communications link to that site and provide what it needs with the need for sor development. It should be noted here that the project was selected and previewed before starting the architectu design, it has been achieved the actual function of the building and all the aesthetic factors also, the building has al been directed to meet the purposes of ventilation and lighting, This is shown clearly in Figure (2-1).

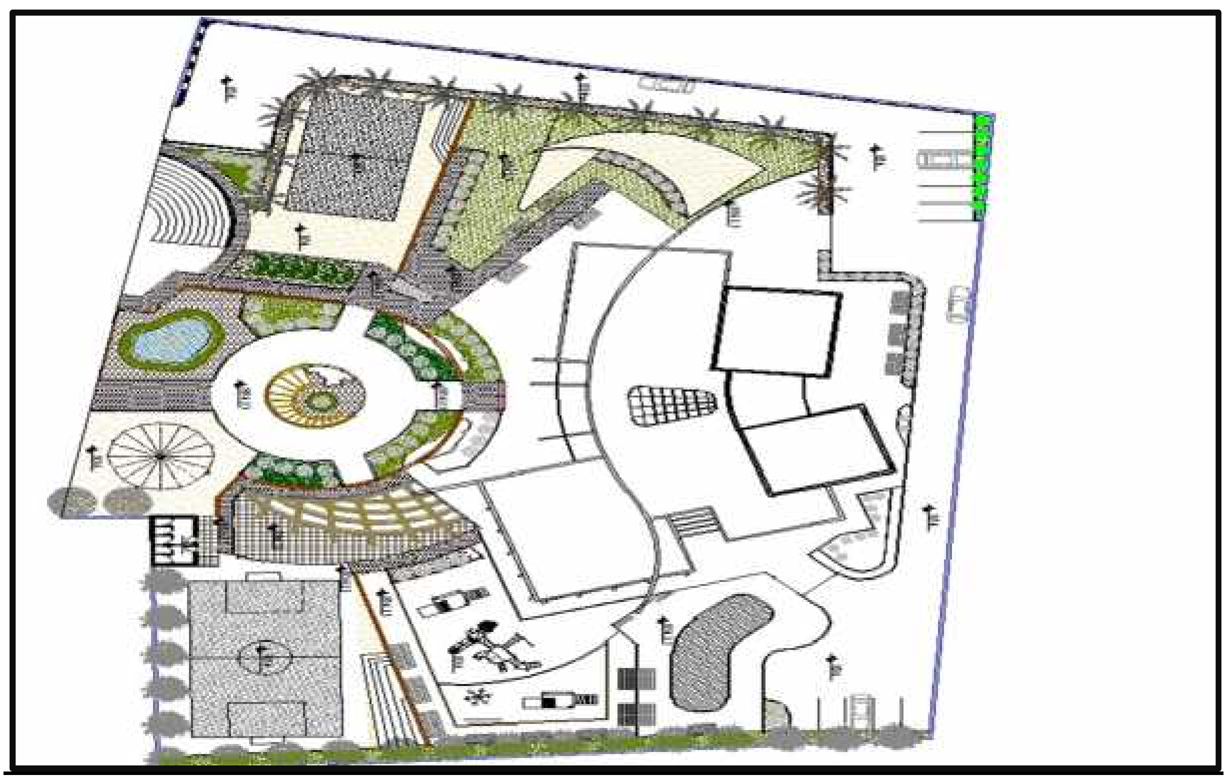


Fig 2.1: Project site

2-4 Site importance:

Hebron has a great location between the cities of Palestine, geographical and economic level, and the existence Palestine Polytechnic University in Hebron make it a destination for students from various Palestinian cities, a there were a variety of reasons that led to the selection of Wad AL-Hareyah area for establishing of the buildi .And the most important of these reasons, the existence of Palestine Polytechnic University buildings in the are and features that were available at the site of this project has been taken into account and are as follows:

1- Region's need for such a project.

2- Provide a piece of land area to accommodate the size of the project.

3- Vitality of the region.

4- Easy access to the site.

5- Keep the natural advantages of the site, qualifies it to contain the project.

2-5 Wind and sun movement:

The study of the movement of the sun and the wind are important factors in building analysis, the sun is want energy, and directing the building toward the sun with protect it from brightness from the western region is successful way to get the maximum amount of solar energy in the cold days, minimizing the amount of ener consumed for heating.

Wind has significant impact on the buildings, it is the horizontal load affects the walls of the building, and thus the structure ,it must take into account the effect of wind and the sun on the building to be designed so as to me design requirements relating to ventilation and natural lighting.

Figure 2-2: illustrates the impact of these factors, the movement of the sun seem clear, Where most of the parts of the building covers since sunrise until sunset as shown in the Figure:

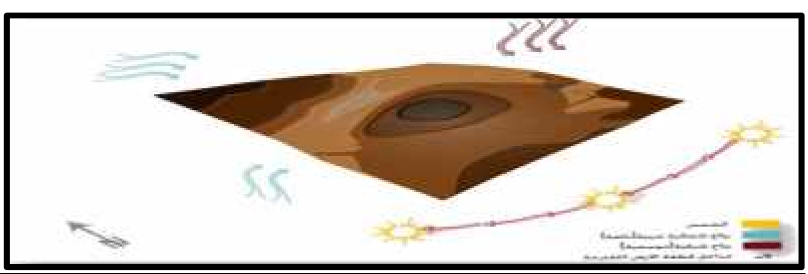


Fig 2.2: Direction of the building

2-6 Floors Description:

The project consists three floors is characterized by the diversity of services. Distributor on the building in the engineering structure, which is designed with artistic and beautiful grounds.Which helped to organize the necessary services and arrangements, and provide places to rest on each floor.

The total area 10000.235 m 2, and the ground floors will be described and the first, second, third and fourth as follows:

2-6-1 Ground floor:

This floor contains several sections as:

1- reception hall

2-.restaurants

3-bathroom

4-video conference

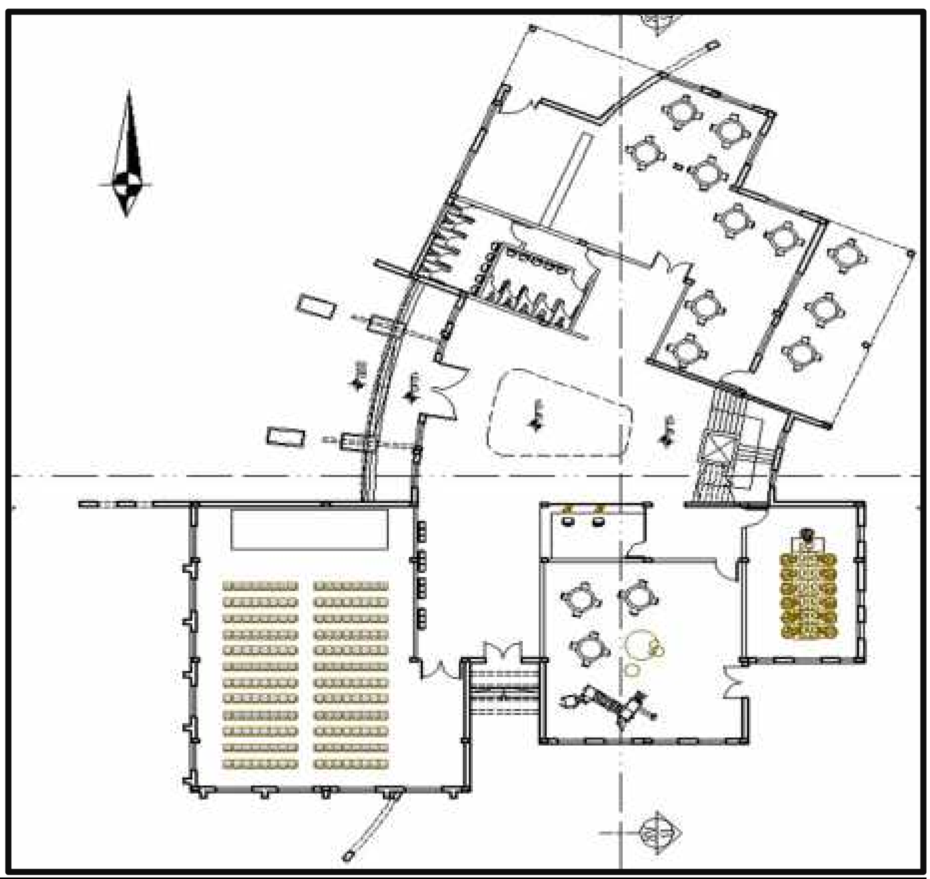


Fig 2.3: Ground floor

2-6-2 First floor:

This floor contains several sections as:

1-management office

2-readers room

3-waiting halls

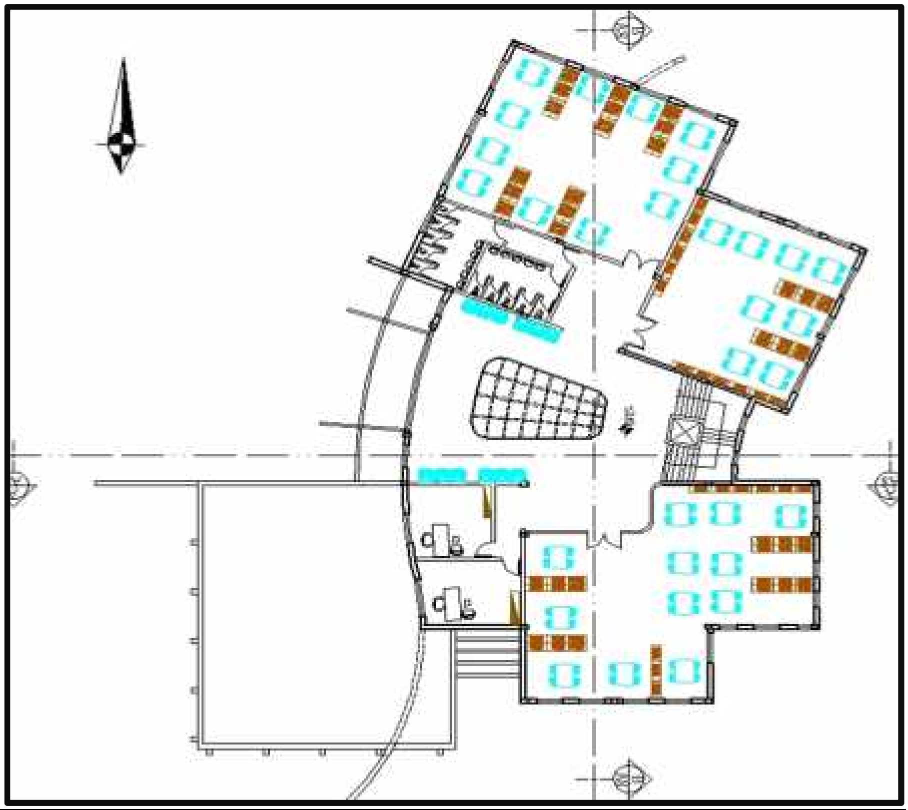


Fig 2.4: First floor

2-6-3 Second ground:

This floor contains several sections as

1. management office
2. computer labs
3. bathrooms
4. video conferance

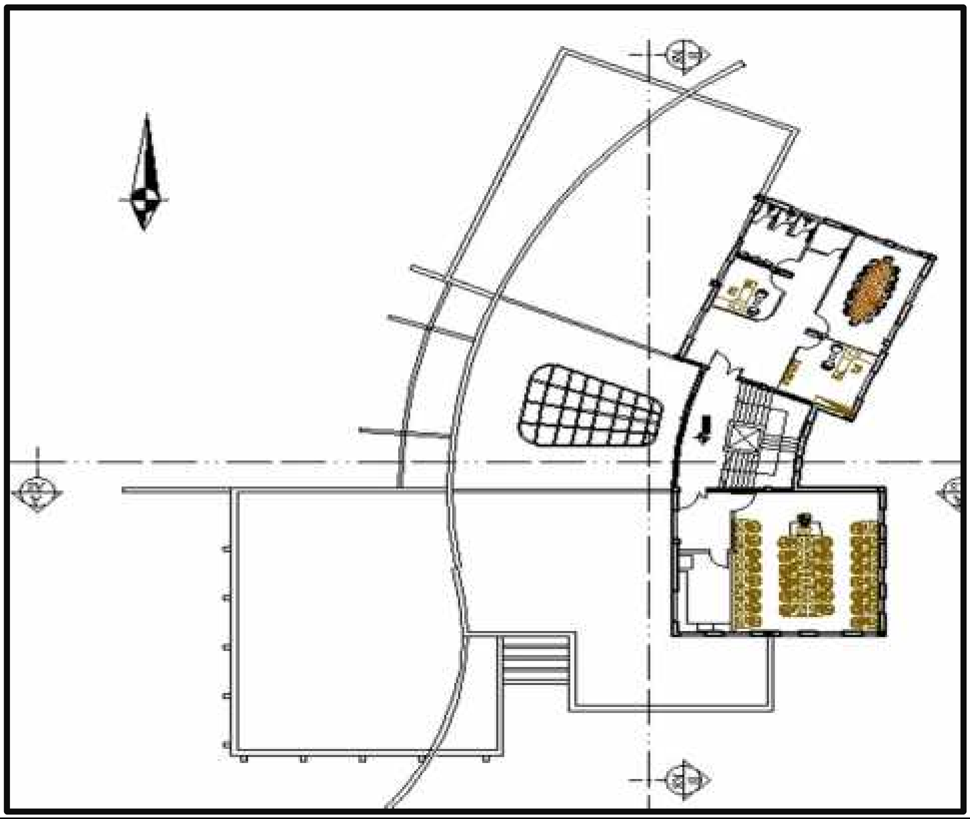


Fig 2.5: Second floor

This table also shows the distribution of space for all the floors are as follows

Table 2-1 the distribution of spaces on the floors.

Floor	Ground	First	Second	Total
Area (m2)	1989.063	1701.073	1309.864	5000.587

2-7 Elevations:

The interest of the architect from the interfaces be great ,as the interfaces must be in general sight in keeping with the nature of the building and its uses, so the engineer take into account every detail of the interface, details in terms of materials used, the distribution of the holes, varying elevations and retreats, and other factors that highlight the beauty interface design.

2-7-1 Southern elevation:

This interface shows the distinctive building openings, and some overlaps in the building, so that the attic lends clearly a kind of beauty and vitality remarkable, and use here also the same user stone type in other interfaces also been arranged openings and windows, as in the other interfaces, and make it a distinctive character exquisite architecture and a touch.

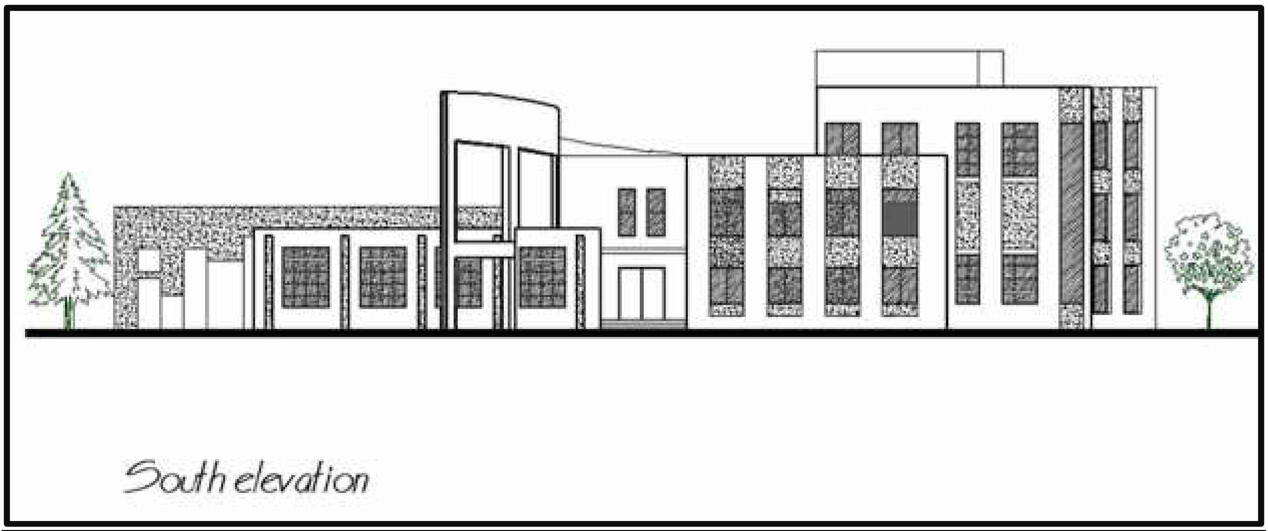


Fig 2.6: Southern Elevation

2-7-2 Northern elevation:

Oppositlythis elevation with the southern elevation, in terms of overlapping horizontal blocks and vertical, which gives the building theorist wonderful aesthetic, as well as the multiplicity of openings used, and the use of more than one type of stone to distinguish the site openings on the one hand, and give a view of aesthetic unique, from other systems where marked this elevation using glass along the floors and in the stairs area. Here, too, it used the same stone used in other interfaces type as was arranged openings and windows, as in the other elevation.

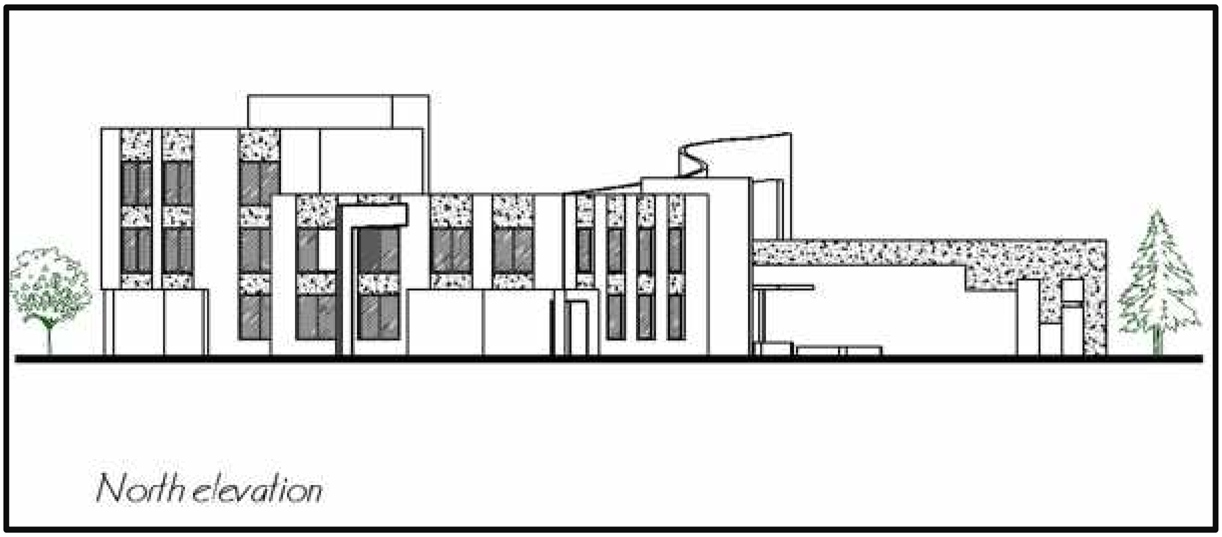


Fig 2.7: Northern Elevation

2-7-3Eastern elevation:

this elevation has a good perception of the size of the project to the viewer, and it consist a beautiful openings like other elevations.

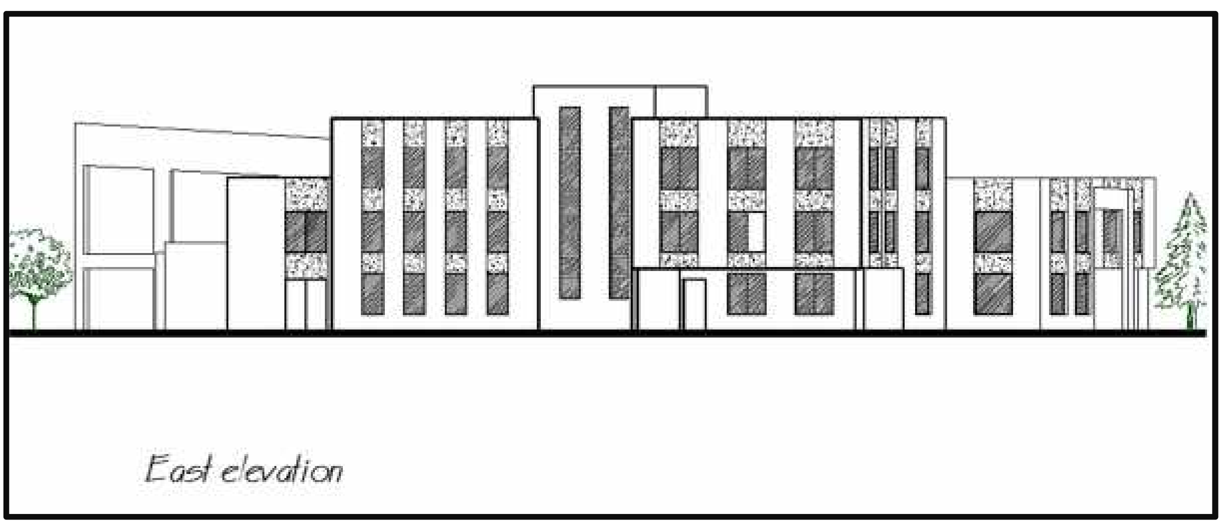


Fig 2.8 Eastern Elevation

2-7-4 Western elevation:

This elevation is considered the main facade of the project, and in this elevation continuity stories building appear until the last floor, where it appears in this elevation continuity of windows to view the building, and this highlights the architectural beauty of the elevation, and use here also the same user stone in the other elevations type as was arranged openings and windows, as in other elevations.

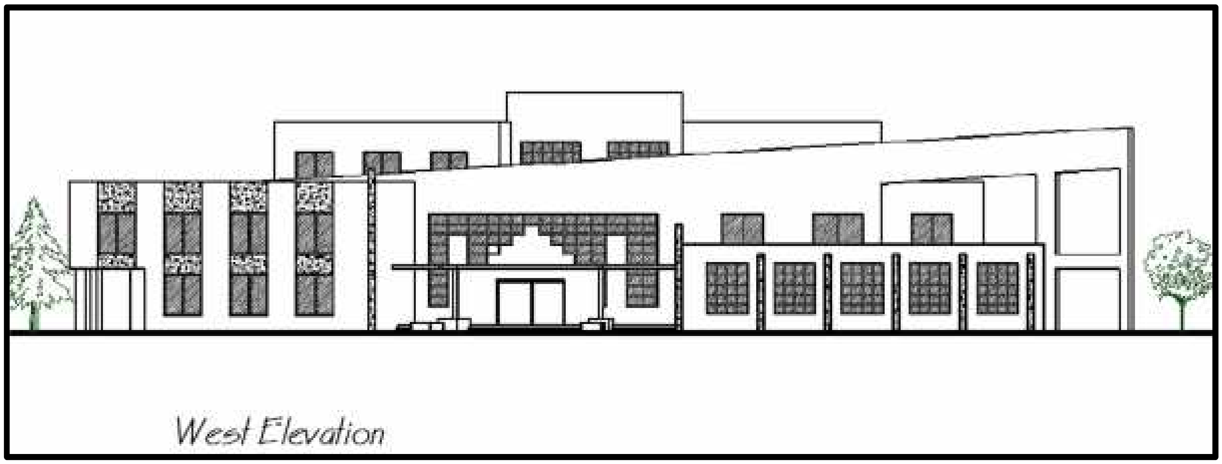


Fig 2.9Western Elevation

2-8 Sections:

2-8-1 A-A section

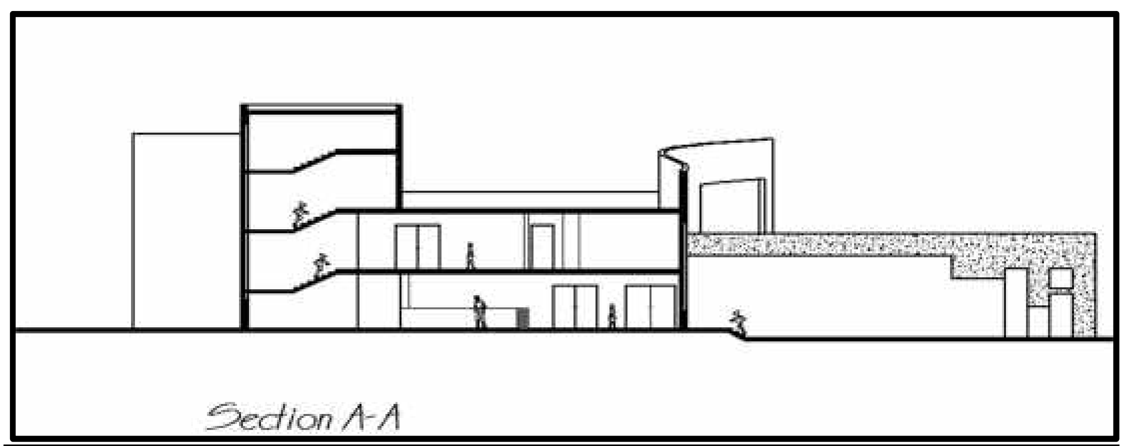


Figure2.10 A-A Section

2-8-2 B-B section:

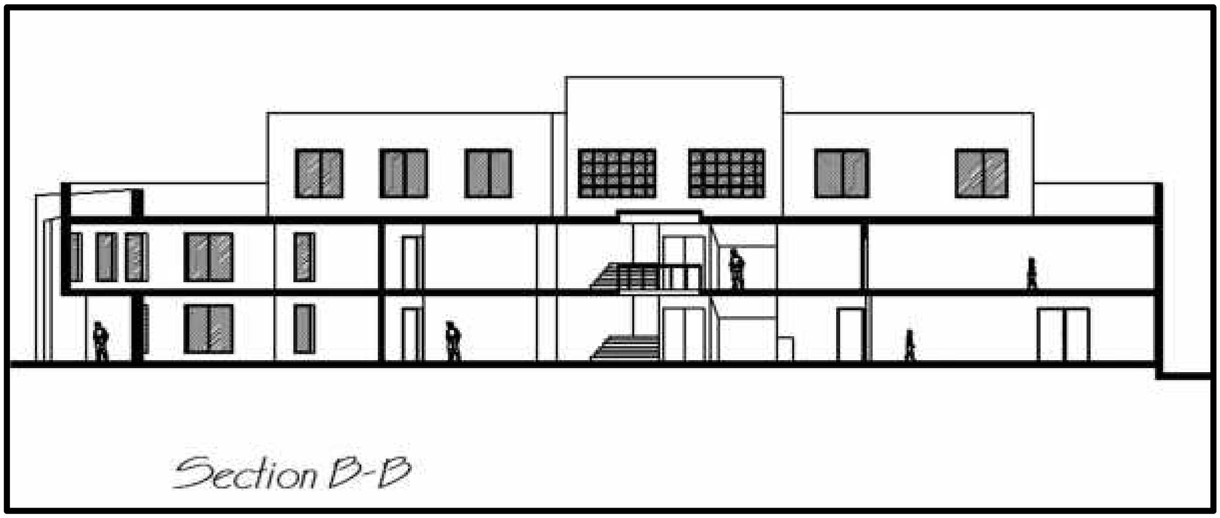


Figure 2.11 B-B Section

2-9 Movement description:

Horizontal and vertical movement in the inside of the building in all the floors are linear, through the passageway between the blanks with clarity and ease of movement as well as by the elevators and stairs. Elements of the movement in the buildingmay includethe formulation of architectural elements, because of their importance, in such projects due to the diversity and interest in them, and have emerged as we have in this project a group of those elements, including:

1-elevators.

2-stairs.

3-Corridors

2-10 Entrances:

This project contains two entrances; one of them is the main inwestern facade
and the other sub in the southern facade.

Chapter 3

structural Description

structural Description

3.1 Introductions:

The description of any process are not limited to a particular aspect of its aspects but it is described in depth and all internal details of are considered an integral part of it. After identifying the architectural side of the library and learn about itsaesthetic requirements, it was necessary to guide the study to identify the structural part, it will be possible to operated, taking into account safety and security.

As structural design mainly depends on the design of all structural elements ,so that resist all loads that affect them. Therefore must all these elements describe an accurate description, meets the engineering calculations for the project requirements, as well as to maintain the architectural design and not to change it.

3.2 The goal of structural design:

Structural design mainly aims to produce a balanced origin of all the engineering and construction aspects and resistant to all external influences loads of dead and live loads and also environmental impact of earthquakes, wind and snow. And the determination of the structural elements based on:

A. **Safety**: it is achieved by selecting structural sections able to withstand the forces and stresses resulting therefrom.
B. **Cost**: is achieved by building materials and the suitable and sufficient sections for the purpose for which will be used for it.
C. **Serviceability**: in terms of avoiding deflection and to avoid the appearance of cracks in a negative impact on the desired architectural theorist.
D. **Shape and aesthetics of origin.**

3.3 Theoretical studies of the structural elements:

Theoretical study is a major and important part needs to be done to complete the process of analysis and design, as it which can access the best of the analysis processes, so you must study the structural elements well and determine the loads located on each element to reach a solid and safe design and method of the appropriate action.

3.3-1 loads and classification:

Must all structural elements that are designed be able to carry loads without incident by a collapse of this facility, these loads: dead loads, live loads, environmental loads.

1. Dead load:

Its loads caused by the weight of the building, which consists of weights of building materials used. Which include all the structural elements and fixtures, it loads remain permanently in the building, a fixed amount and direction.

As regard to the specific gravity of the materials used are as follows:

Table 3.1 specific gravity of materials

No#	**materials**	**Density KN\m³**
1	Tiles	23
2	Mortar	22
3	Reinforcement concrete	25
4	Bricks	9
5	Plastering	22
6	Sand	16

2. Live load:

It loads affecting the buildings and construction because of their different uses, or uses any part thereof, including distributed and concentrated loads, which include:

a- Weights of people, users of facilities

b- Dynamic loads, such as devices, which give rise to vibrations, affect the building.

c- Static loads, which can change its place from time to time, such as houses furniture and appliances, and the stored material, furniture, appliances and equipment.

Table 3.2 shows the value of live loads depending on the quality of use of the building by the Jordanian code:

Table 3.2: live load

#NO	Using	Live load KN\ m²
1	Parking	9.0
2	schools	5.0
3	hospitals	5.0
4	commercial buildings	4
5	Restaurants &Library	5.0
6	residential buildings	2.5
7	educational buildings and colleges	5.0

3. Environmental loads:

It loads resulting from natural sources, a third type of loads that must take them into account in the design, these loads are:

A. Wind:

A horizontal force affect the building and shows the impact on high-rise buildings. It forces affecting on the buildings or facilities or their parts, and be positive if they are the result of pressure and negative if they are the result of tension, measured in kilo Newton.

Determining wind loads according to code (UBC 97) depending on the height of the building above the ground, and the location from where the briefing of buildings, whether high or low and designed shear walls by wind design for this region, where wind loads calculated according to cod speed (UBC 97)

P=Ce*Cq*qs*Iw

Ce: combind height.

Cq :pressure coefficient of structure.

Iw importance factor.

P:design wind pressure.

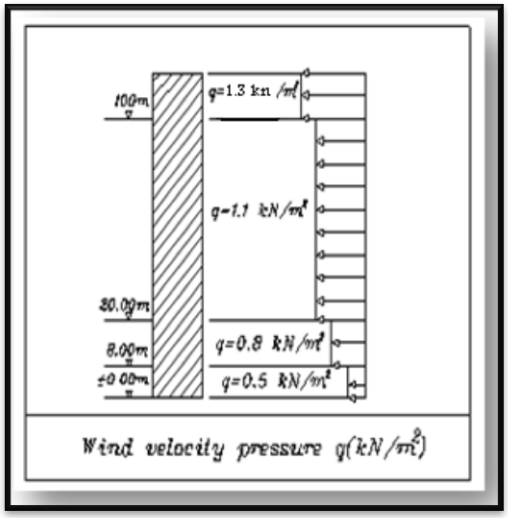


Fig 3.1 the effect of wind speed on the pressure on the value of the building

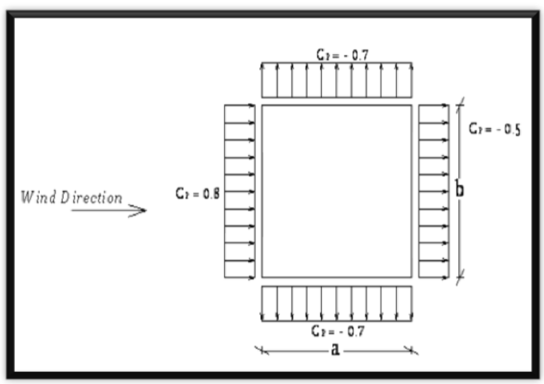


Fig 3.2 the effect of the wind direction on the pressure on the value of the building .

B. Snow:

Are loads that can be exposed to the building through the accumulation of snow, and snow loads can be evaluated based on the following grounds:

1. building height above sea level.

2. Slop of exposed surface of the snow.

The following table shows the value of snow loads according to height above sea level by the Jordanian code:

Table 3.3 the value of snow loads according to height above sea level

Snow load KN\m²	Building height above sea level (m)
0	H < 250
(h-250)\1000	500 > h > 250
(h-400)\400	1500 > h > 500
(h-812.5)\250	2500 > h > 1500

C. Earthquake:

One of the most important environmental loads affecting the building. It is a horizontal and vertical forces generate moments, including the determination of buckling and determination of the overturning , and can be resisted by using shear walls, designed thicknesses and reinforced enough to assure the safety of the building when exposed to such loads that must be considered in the design to minimize the risk process, and maintain the performance of the building to function during earthquakes, seismic loads and shear forces are determined and depending back to (UBC79).

3.4 Practical tests:

Geotechnical studies for the site means by all businesses that have a relationship to explore the site and study the soil, rock and groundwater, and analysis of information and translate it to predict the way the soil behavior, when built upon, and more what concerns structural engineer is to get the durability of the soil (Bearing Capacity) necessary for the design of the foundations of the building and the durability soil of the site equal to 400 KN per square meter on the grounds that the type of soil is rocky.

3.5 Structural components of the building:

The building is a resultant of the outcome of the structural elements with each other, to become an integrated one block do not show any reproach ,upright in front of loads that are exposed, and the most important of these elements, slabs, beams, columns and load-bearing walls and foundations and others.

All the structural elements operate as a single unit, where loads passed from slab to the beam and then to the bearing walls or columns in order to finally end to the foundation, the following image describes how to move loads at the facility generally:

1) Foundation.

2) Columns.

3) Beams.

4) Slabs.

5) Shear walls.

6) Stairs

7) Retaining Walls.

8) Bearing Walls .

9) Joint System.

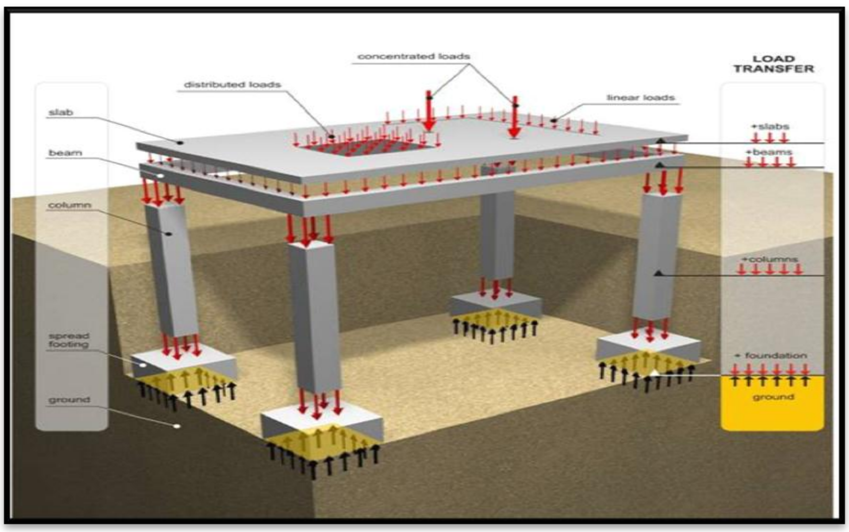


Fig 3.3 Transmission of loads within abuilding

3.5.1 Slabs:

Is a structural element capable of transmitting vertical forces. Resulting from loads acting on them to load-bearing structural elements in the building such as beams, walls, columns, without exposure to deformities.

The choice of the optimal type, depending on several factors including:

1. Spans between columns.
2. Function of origin.
3. Cost.
4. Time, easy.

In General, these types of structural elements that we use some of them in our project:

1. Solid slabs:

A. One way solid slabs.

B. Two way solid slabs.

2. Composite slabs.

3. Ribbed slabs:

A. One way ribbed slabs.

B. Two way ribbed slabs.

4. Flat slabs

<u>One-way solid slabs:</u>

Used in areas that are exposed to a lot of live loads, in order to avoid vibration due to low thickness, it is used in the slabs of stairs case as shown in Figure 3.4:

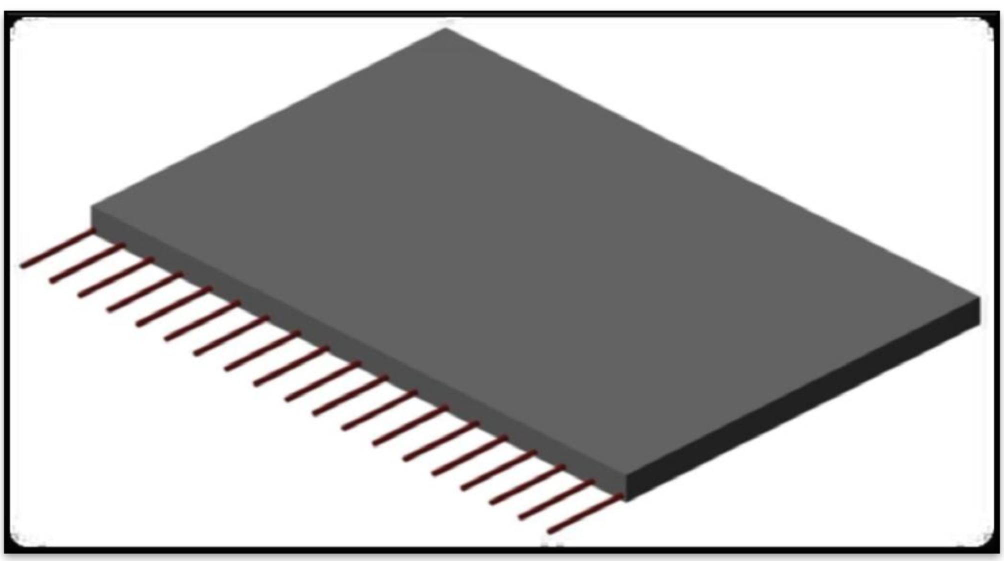


Fig3.4 One way solid slab

Two-way solid slabs:

This type is used when loads affecting be greater than the amount that can resisted by one-wayslabs, and then we design this type of components, they can resist loads more, where the main reinfocementis distributed in two directions. Illustrated in Figure 3.5

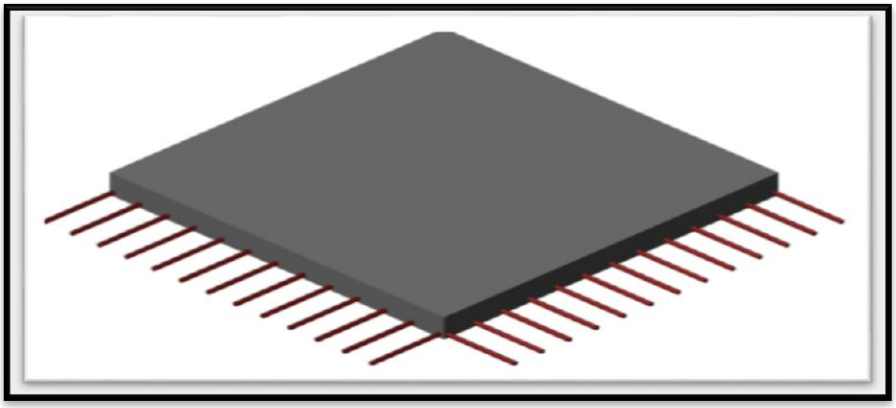


Fig3.5 Two way solid slab

Composite slabs:

This type of slabs used when the need for large distances without the use of columns in the consolidation process. It was renamed (composite slabs) to describe any construction of buildings that involve multiple different materials. There are several reasons for the use of composite materials including increased strength, aesthetics, and environmental sustainability.

In Structural Engineering, having a composite construction when it has to be two different materials together strongly so they work together as a single unit from the structural point of view. When this happens, it is called a composite work. It includes a common example of steel beams supporting the floor of concrete slabs. As shown in figure 3-6

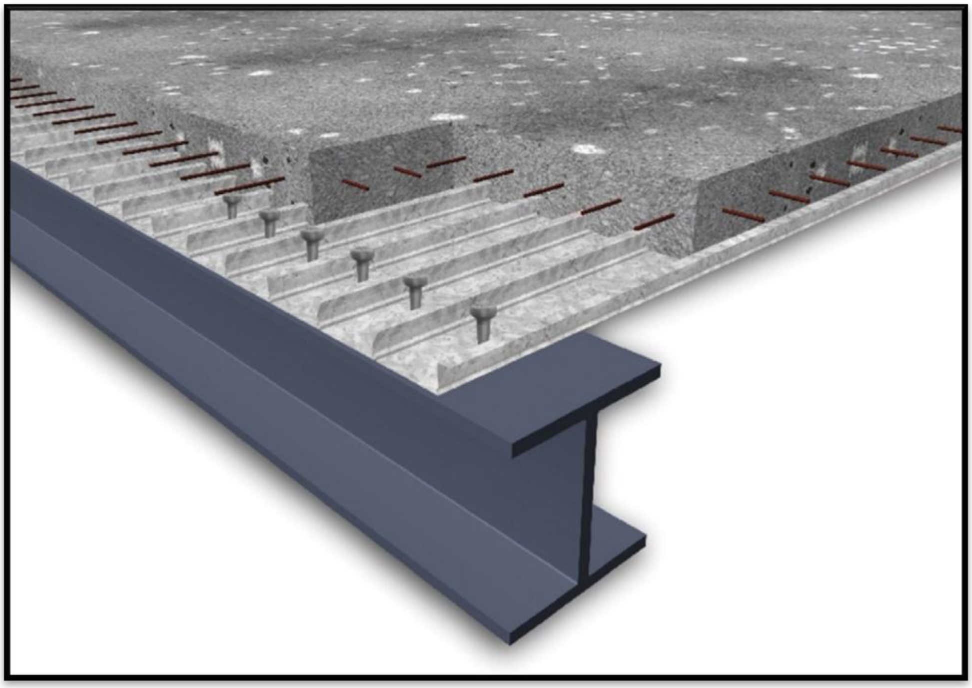


Fig3.6 Composite slab

One way ribbed slabs:

Is the most popular methods used in the design of slabs in this country. It consists of a row of brick, followed by rib, and a reinforcement in one direction as shown in Figure3-7:

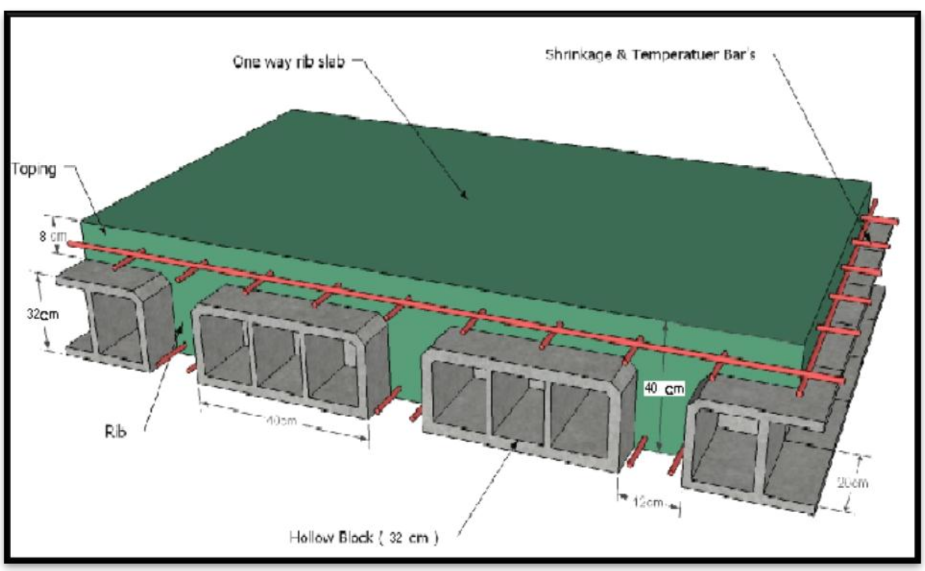


Fig3.7 One way ribbed slab

Two way ribbed slabs:

Similar to the previous in terms of components, but differ in terms of reinforcement be two-way. The load is distributed in all directions, and taken into account when weighing the expense of bricks and rib in both directions, as shown in Figure 3-8

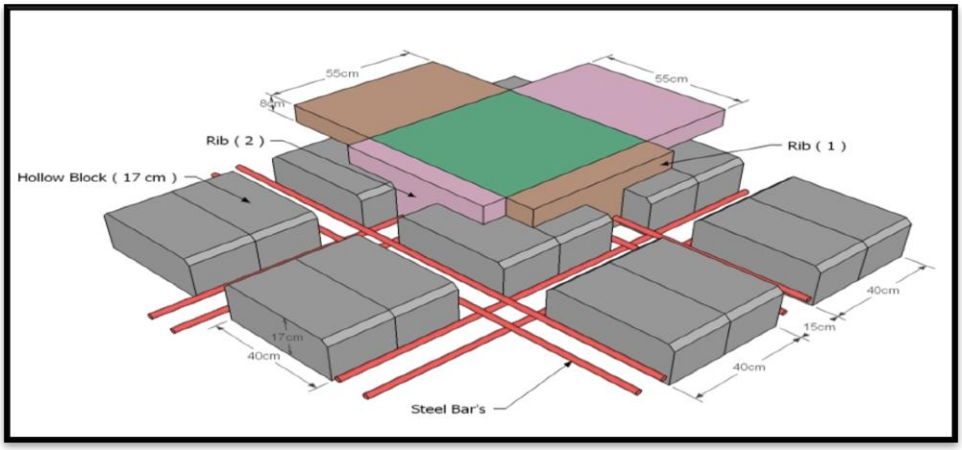


Fig3.8 Two way ribbed slab

3.5.2 Beams:

It is an essential structural element in the transfer of loads from the slabs to the columns, which are two types:

1. hidden beam :have a height equal to the height of the slabs.
2. dropped beam: have a height greater than the height of the slabs.We highlighting the excess part of the beam in both directions a bottom (Down Stand Beam) and upper (Up stand Beam) so that these bridges are called (L –section), (T-section).

It is also used Tie beams in the building in the foundations to prevent sliding and falling foundations each one separately. andb due to the different distances between the columns in the building to be designed in this project, in addition to the loads, the beams that will be used in the slabs will be hidden beams and other drop.

We attach a variety of shapes and forms which describes the types of beams as used as follows:

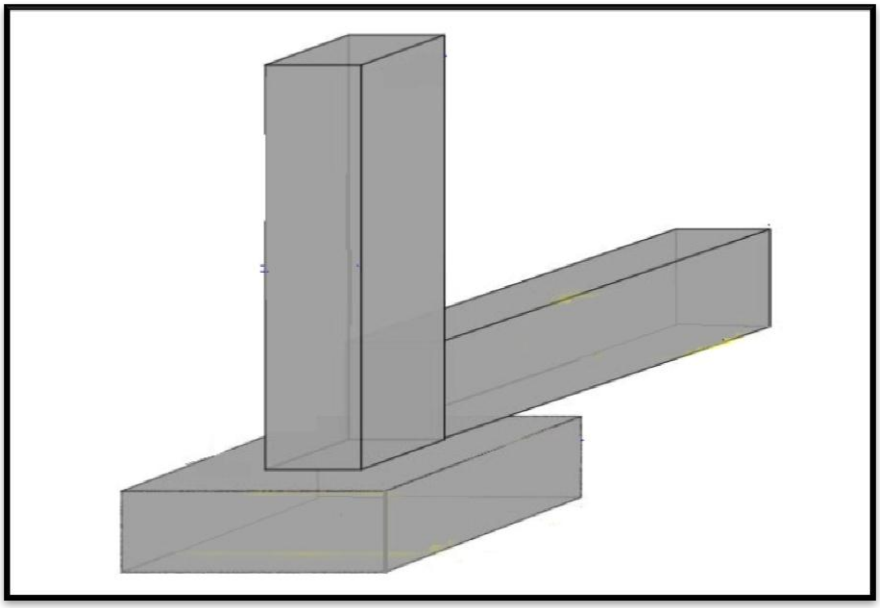


Fig3.9 Tie beams

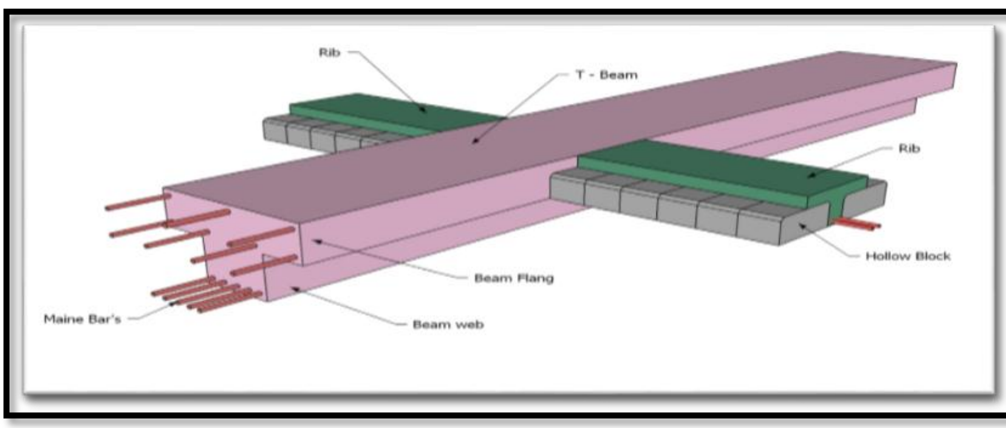


Fig 3.10 Drop beams

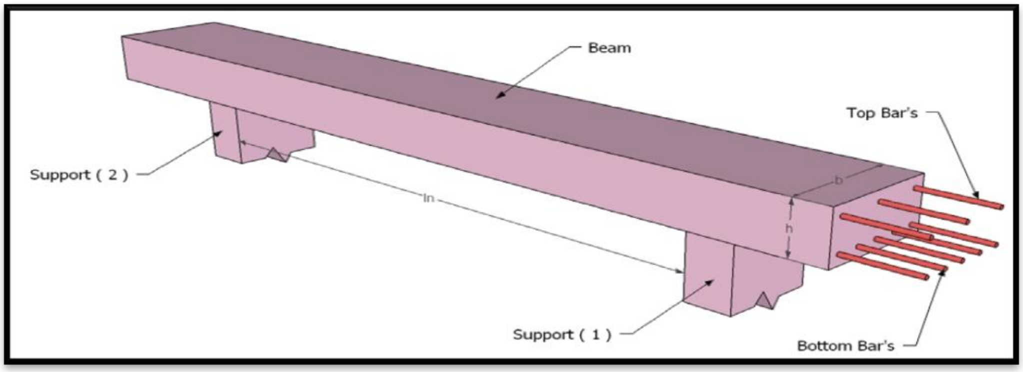


Fig 3.11 Hidden beams

3.5.3 Column:

Columns are considered key member of the transport loads from slabs and beams to foundations, and so it is a structural element necessary for the transfer of loads and the stability of the building. So it must be designed to be capable of carrying and distributing loads located on them.

There are two types: short and long columns, and columns have many forms, including rectangular and circular and polygon and square. Another classification of columns in terms of the material used including concrete and metal and wood.

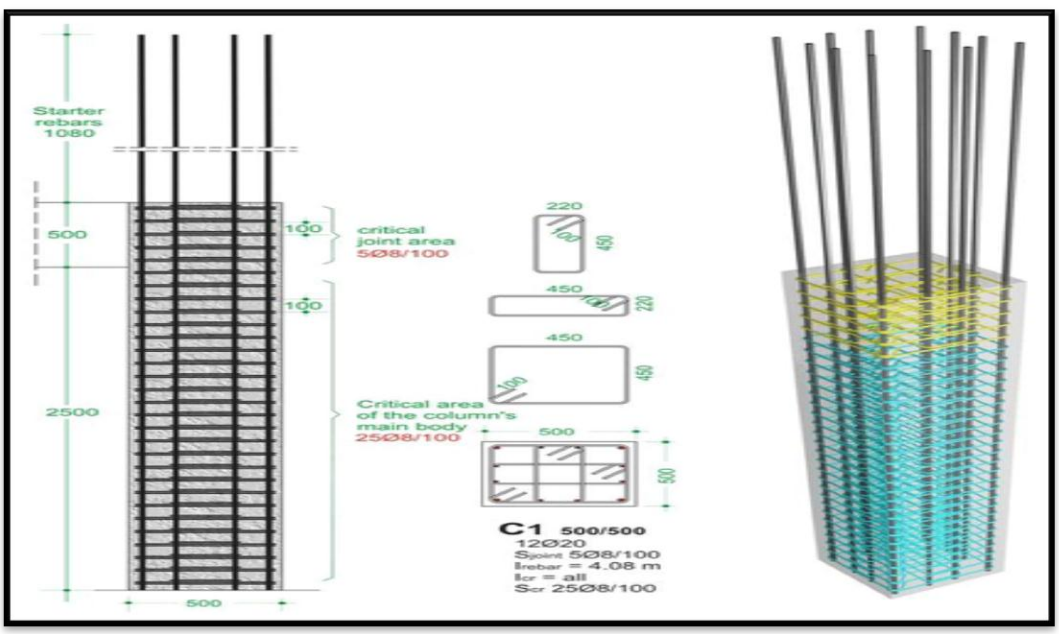


Fig 3.12 One of types of columns

3.5.4 Bearing wall:

Structural elements are resistant to vertical and horizontal forces located them, it is mainly used to resist horizontal loads such as wind and earthquake forces and called shear walls.

These walls are reinforcing on two layers of steel in order to increase their efficiency to resist horizontal forces,we determine the bearing walls and distribute them to the building, and the walls are bearing walls of the stair, and the walls of the elevators, and other walls that start from the foundations of the building.

The walls bear vertical movable weights, also works as a shear wall to resist horizontal shear forces that exposed her origin, and it must be available in both directions, taking into account that the distance between the center of the resistance posed by the shear walls in each direction and the center of gravity as little as possible of the building. And these walls must be sufficient to prevent or reduce the generated torsional moments and its effects on the walls of the building resistance to horizontal forces.

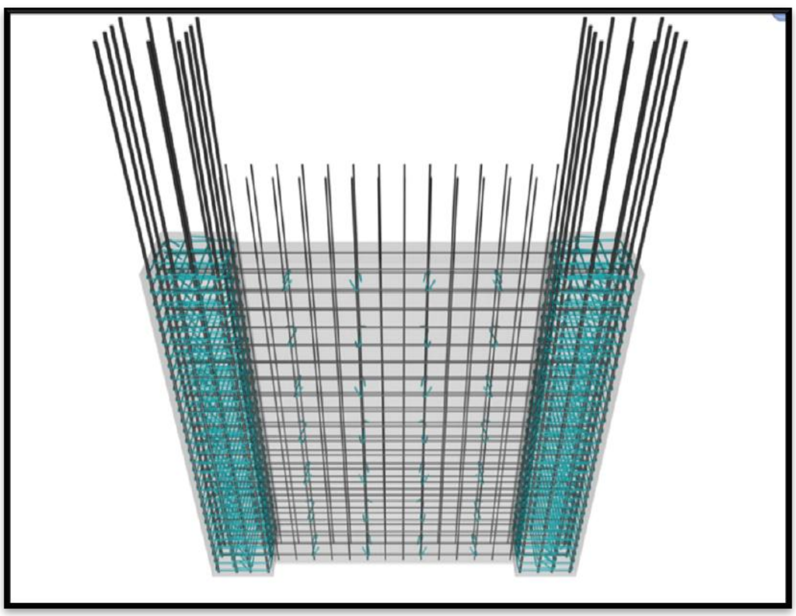


Fig 3.13 shear wall

3.5.5 Foundation:

Although the foundation is the first element has been implemented at the building of origin, however, it is designed after the completion of the design of all structural elements of the building.

Foundations is a link between the structural elements of the building and the ground, and to find out the weights and loads located on them, the loads located on the slabs moves to the beams and then to the columns and finally to the foundation, and these loads are to design of the foundations, and based on the loads located on them, and the nature of the site, we select the type of foundation used.

It is expected to use the foundations of different types, depending on the soil bearing strength, and loads located on each, due to the shape of origin and include it to fit with the topography of the ground.

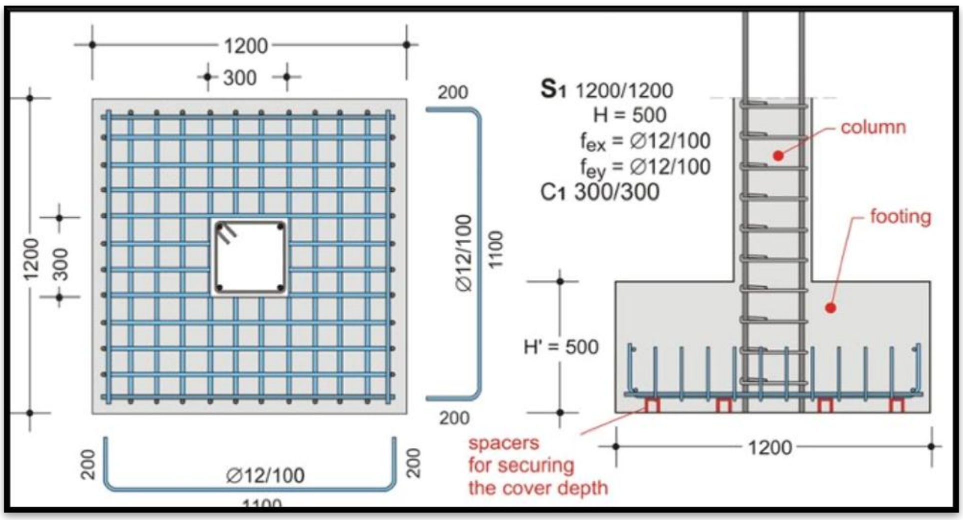


Fig3.14 Foundation plan **Fig3.15 foundation section**

In Figure 3-14, 3-15 shows how to transfer loads from the building to the foundation through the column, and to clarify the process of soil resistance to loads located from the building and also describes the distribution of steel in the foundation.

3.5.6 Stairs:

Is responsible for vertical transmission between the classes in the building element, where the floor is divided into small high-altitude represents the height of a steps. The stairs are designed structurally as one way solid slab.

Clearly it has been used in our project distributed throughout the project, as well as taking into account the structural design loads resulting from the weight of the electric elevator.

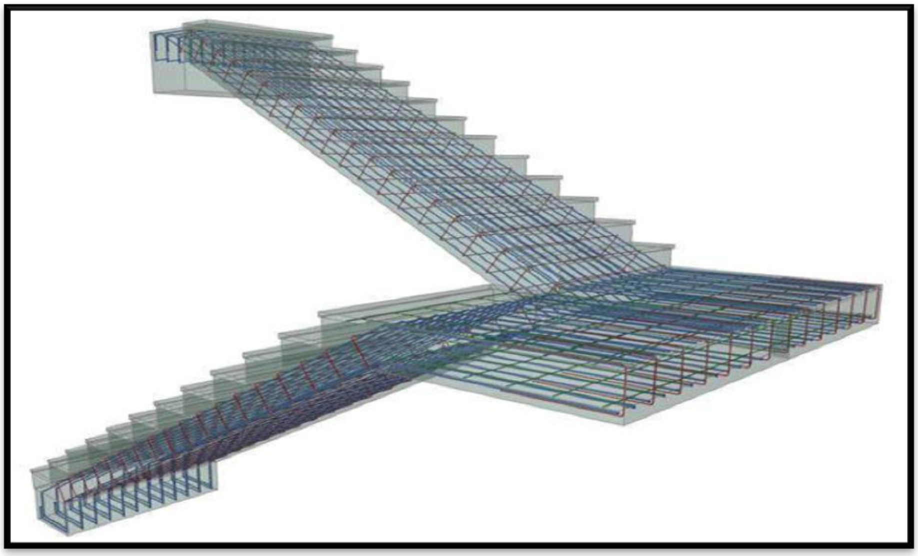


Fig 3.16 stairs

3.5.7 Retaining walls:

These walls are built to support soil and water behind them and the resulting pressure from the soil, trying to fluctuate or move this wall, and retaining walls designed to resistant the weight of the vertical and horizontal soil pressure and lifting of groundwater forces.

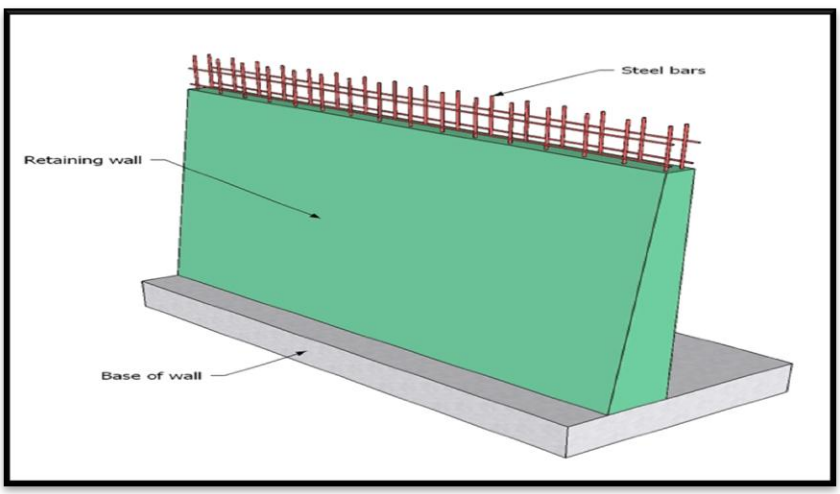


Fig3.17 Retaining walls

3-5-8 Expansion joints:

In large horizontal dimensions of facilities, or special shapes are used thermal expansion joints. The separator is placed if the width of origin is greater than 40 meters , and therefore to allow for expansion of origin without leading to the occurrence of cracks. And have some requirements:

1. We must use the thermal expansion joints in a block of origin, so that these dividing reach to the upper face of the foundation without impenetrable.

Great distances are considered of the building block dimension as follows:

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

2. The width of the expansion joints at least 3cm.

Chapter 4

Structural Analysis & Design

Structural Analysis & Design

4.1 Introduction.

4.2 Design method and requirements.

4.3 Thickness of one way Rib slab.

4.4 Design of topping.

4.5 Design of one way Rib slab pos.(R 0-9).

4.6 Design of Beam pos.(B25).

4.7 Design of Solid Slab.

4.8 Design of Column.

4.9 Design of Stairs.

4.10 Design of Shear Wall.

4.11 Design of Isolated Footing.

4.1 Introduction:

Many structures are built of reinforced concrete: bridges, buildings, retaining walls, tunnels, and others.

Reinforced concrete is logical union of two materials: plain concrete, which possesses high compressive strength but little tensile strength, and steel bars embedded in the concrete, which can provide the needed strength in tension.

Plain concrete is made by mixing cement, fine aggregate, coarse aggregate, water, and frequently admixtures.

Understanding of reinforced concrete behavior is still far from complete, building codes and specifications that give design procedures are continually changing to reflect latest knowledge.

Structural concrete can be classified into:

- Lightweight concrete with unit weight from about 1350 to 1850 kg/m^3.
- Normal weight concrete with unit weight from about 1800 to 2400 kg/m^3.
- Heavyweight concrete with unit weight from about 3200 to 5600 kg/m^3.

4.2 Design method and requirements:

The design strength provided by a member is calculated in accordance with the requirements and assumptions of ACI_code (318_08).

- ✓ 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,
Strength provided ≥ strength required to carry factored loads.

NOTE:

The statically calculation and the key plans dependent on the architectural plans.

- ✓ **Code : ACI 2008**
  UBC
- ✓ **Material :**

Concrete: B300……. fcu = 30 MPa(for rectangular section)

but for rectangular section fc` = 0.8*30 = 24 MPa.

B350…… fc` = 0.8*35 = 28 MPa

Reinforcement steel :The specified yield strength of the reinforcement {fy = 420 N/mm² (MPa)}

Mild steel : A-36

Connection Type : Weld , Bolts

***Factored loads:**

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

$W_u = 1.2\ D_L + 1.6\ L_L$ ACI-code-318-08(9.2.1)

4.3 Thickness of one way rib slab:

***Check Thickness of one way rib slab:**

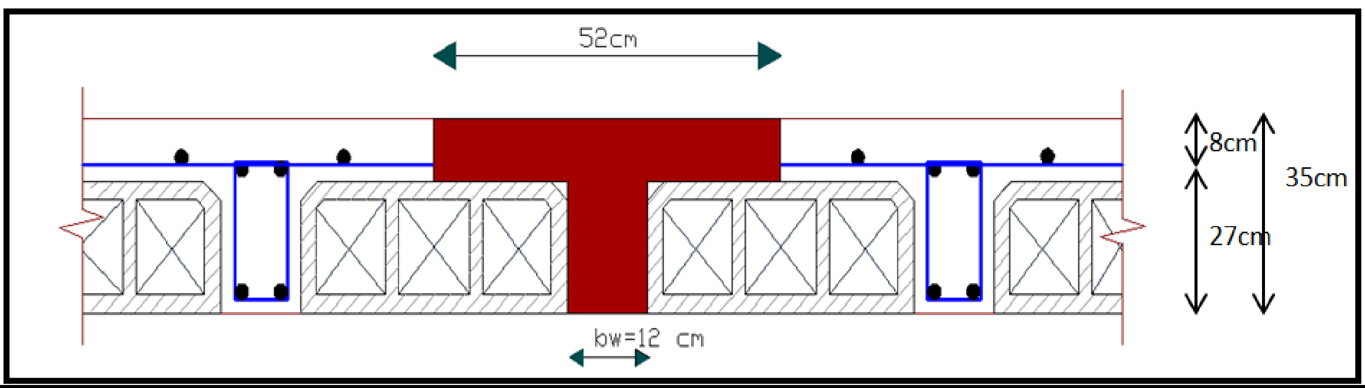


Fig 4.1:Section in one way Rib slab

The minimum required thickness is:

$\frac{L}{18.5} = \frac{6.20}{18.5} = 0.335$ m **for one end continuous supported(R3).**

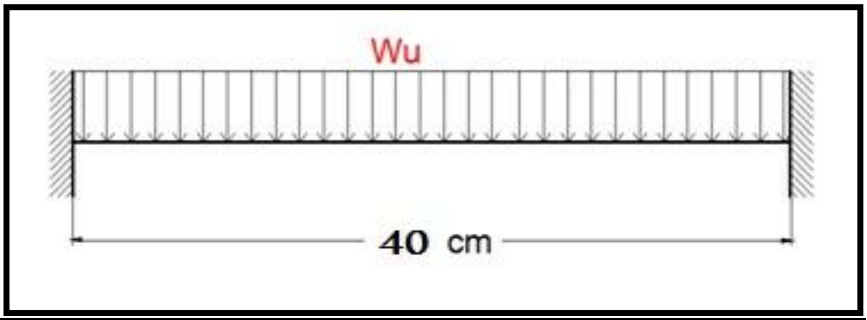
Select h min = 350mm

Note: We solved any deflection by reinforcement.

4.4 Design of topping:

- ✓ **Statically system for topping :**

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



- ✓ **Load calculations:**

Dead load calculations:

Dead load from:	δ×γ×1	KN/m
Tiles	0.03×23×1	0.69
Mortar	0.02×22×1	0.44
Coarse sand	0.07×16×1	1.12
Topping	0.08×25×1	2
Interior partitions	1.5×1	1.5
	∑	5.75

Table(4-1) calculation of the Dead load for topping

Live load :

$L_L = 5\ KN/m^2 \longrightarrow L_L = 5\ KN/m^2 \times 1m = 5\ KN/m$

Factored load :

$W_U = 1.2 \times 5.75 + 1.6 \times 5 = 14.9\ KN/m.$

Check the strength condition for plain concrete, $øM_n \geq M_u$, where ø =0.55.

$M_n = 0.42\ \lambda\sqrt{f'_c}\ S_m$ **(ACI 22.5.1, equation 22-2)**

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

$øM_n = 0.55\times0.42\times1\times\sqrt{24}\times1066666.67 = 1.21\ KN.m$

$M_u = \frac{W_u L^2}{12} = 0.198\ KN.m$ **(negative moment).**

$M_u = \frac{W_u L^2}{24} = 0.099\ KN.m$ **(positive moment).**

$øM_n = 1.21\ KN.m >> M_u = 0.198\ KN.m$

No reinforcement is required by analysis. According ACI 10.5.4, provide $A_{s,min}$ for slabs as shrinkage and temperature reinforcement.

$\rho_{shrinkage} = 0.0018$ **ACI 7.12.2.1**

$A_s = \rho\times b\times h_{topping} = 0.0018\times1000\times80 = 144\ mm^2/m.$

Step (s) is the smallest of:

1. **3h = 3×80 =240 mm.** ***control*** **ACI 10.5.4**
2. **450mm.**
3. $S = 380\left(\frac{280}{f_s}\right) - 2.5C_c = 380\left(\frac{280}{\frac{2}{3}420}\right) - 2.5\ .20 = 330mm$ **but**

   $S \leq 300\left(\frac{280}{fs}\right) = 300\left(\frac{280}{\frac{2}{3}420}\right) = 300mm$ **ACI 10.6.4**

Take ø8 @ 200 mm in both direction , S = 200 mm <S_{max} = 240 mm … OK

✓ **Design of shear reinforcement:**

$Vu = \frac{W_u L}{2} = 2.98\ KN$

Chick for the strength condition øVc ≥Vu

$øVc = 0.75\times\frac{1}{6}\times\sqrt{fc}\times b\times h$

$= 0.75\times\frac{1}{6}\times\sqrt{24}\times1000\times80 = 48.99\ KN$

Ø*Vc=48.99 KN>>> Vu=2.98 KN

No shear reinforcement is required.

4.5Design of one way Rib slab (R9):

Requirements For Ribbed Slab Floor According to ***ACI- (318-08)*** **.**

bw ≥ 10cm………………………………ACI(8.13.2)

Select bw=12cm

h ≤ 3.5*bw ……………….……….. ACI(8.13.2)

Select h=35cm<3.5*15=52.5cm

tf≥ Ln/12≥50mm ……………………ACI(8.13.6.1)

Select tf = 8cm

- **The effective flange width (b_e), according to ACI 8.12.2 is the smallest of:**
  - $b_e \leq \frac{L}{4} = \frac{3000}{4} = 750\ mm$ **L, is the clear span of the rib.**
  - $b_e \leq b_w + 16h_f$ **= 120+16×80 = 1400 mm.**
  - $b_e \leq$ **center to center spacing between adjacent beams = 520mm.*Control***

✓ **Statically system and Dimensions**

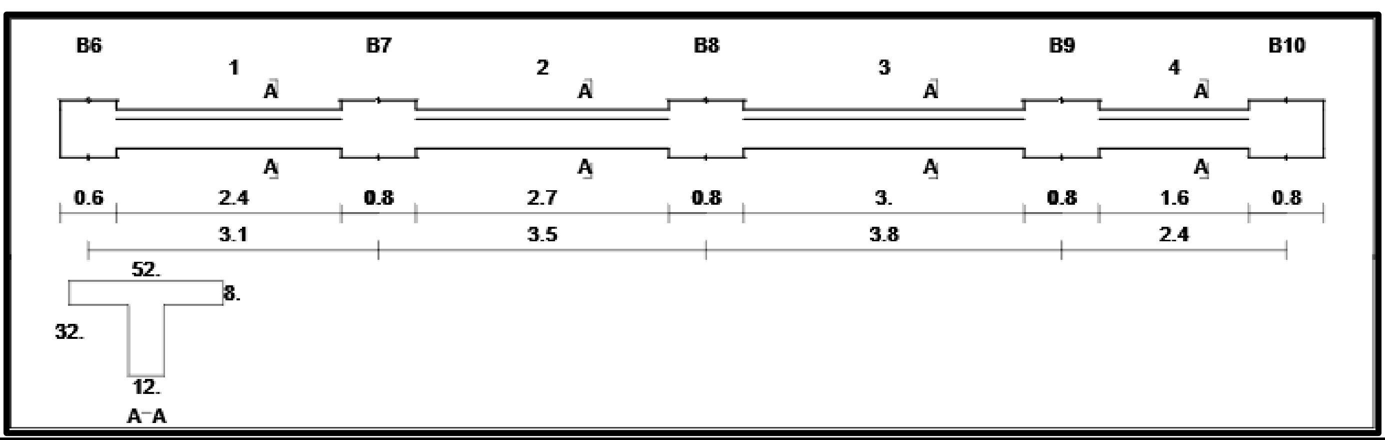


Fig 4.2: Geometry of (R9)

Reaction support for R9 :

Factored					
DeadR	8.16	24.57	25.1	23.73	5.22
LiveR	5.93	16.55	17.15	15.86	4.82
Max R	14.09	41.13	42.25	39.59	10.03
Min R	7.27	31.35	31.6	28.46	3.61
Service					
DeadR	6.8	20.48	20.92	19.78	4.35
LiveR	3.71	10.35	10.72	9.91	3.01
Max R	10.51	30.82	31.64	29.69	7.36
Min R	6.24	24.71	24.98	22.73	3.35

✓ Load calculations:

Dead load calculations:

Dead load from:	$\delta\times\gamma\times b_e$	KN/m
Tiles	0.03×23×0.52	0.3588
Mortar	0.02×22×0.52	0.2288
Coarse sand	0.07×16×0.52	0.5824
Topping	0.08×25×0.52	1.04
Interior partitions	1.5×0.52	0.78
RC rib	0.27×25×0.12	0.81
Hollow Block	0.27×15×0.4	1.62
Plaster	0.02×22×0.52	0.2288
	∑	5.65

Table(4-2) calculation of the Dead load for(R9)

Live load :

Live load /rib = 5 KN/m^2 × 0.52m = 2.61 KN/m.

Factored load :

D_u = 1.2 ×5.65 = 6.78KN/m.

$L_u = 1.6 \times 2.61 = 4.176$ **KN/m. m**

$W_u = 10.956$ **KN/m.**

Dead load service

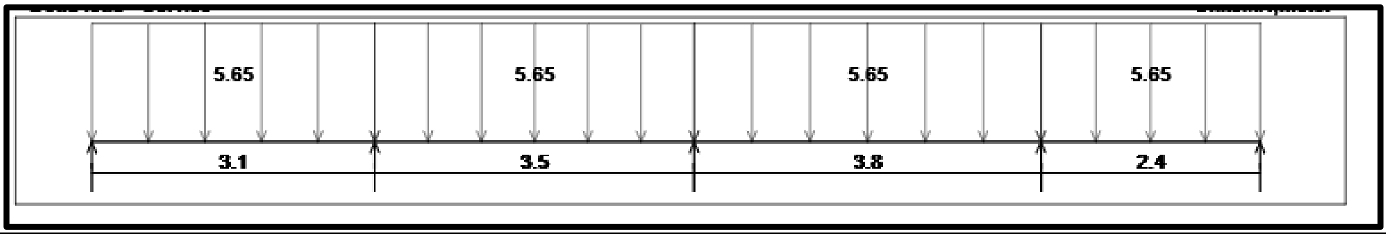


Fig 4.3: Dead load of (R9)

Live load service

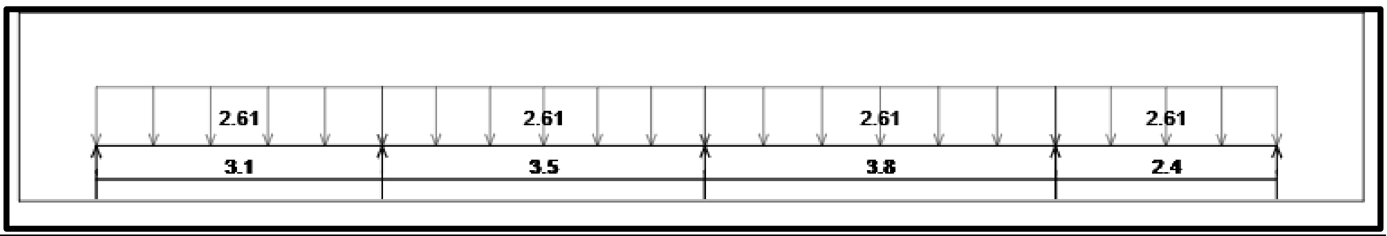


Fig4.4: Live load of (R9)

Flexural Design for (RG-9):

Moment for R9:

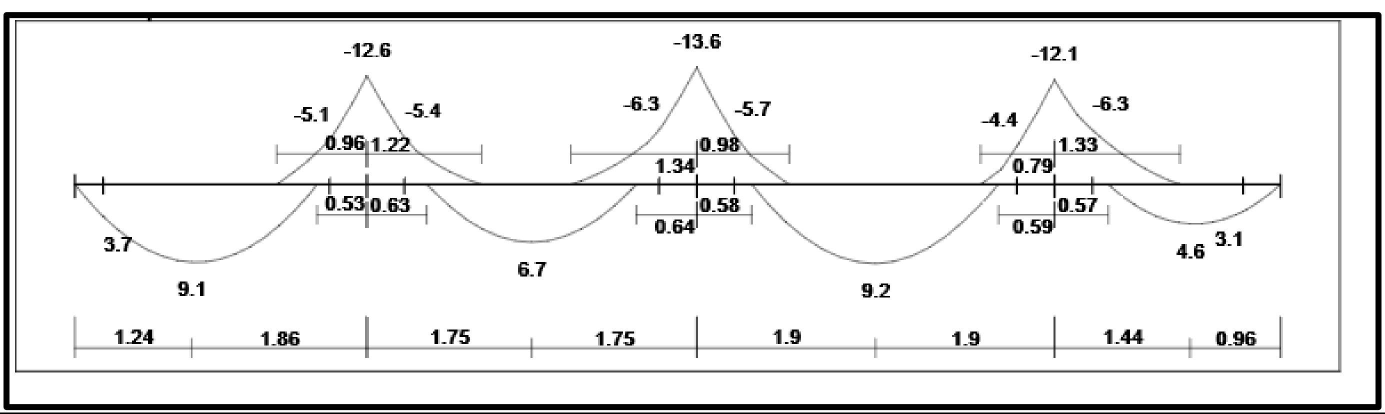


Fig 4.5:Moment envelop of (R9)

Design of positive moment:

M_{umax}**= 9.2KN.m**

Assume bar diameter ø 14 for main positive reinforcement.

d =h- cover - $d_{stirrups}$ $-\frac{d_b}{2} = 350 - 20 - 10 - \frac{14}{2} = 313\ mm.$

Check if a>h_f to determine whether the section will act as rectangular or T- section,

M_{nf} =$0.85.f'_c.b_e.h_f.(d - \frac{h_f}{2})$

$= 0.85 \times 24 \times 520 \times 80 \times \left(313 - \frac{80}{2}\right) \times 10^{-6} = 231.68 KN.m$

M_{nf}≫$\frac{M_u}{\varphi}$= 33.7KN.m, the section will be designed as rectangular section with b_e = b = 520mm.

R_n= $\frac{M_u}{\emptyset b d^2} = \frac{9.2\times10^6}{0.9\times520\times313^2} = 0.2006\ Mpa.$

m= $\frac{f_y}{0.85 f'_c} = \frac{420}{0.85\times24} = 20.59$

ρ= $\frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.59}\left(1-\sqrt{1-\frac{2\times20.59\times0.2006}{420}}\right) = 0.00048$

$A_{s,req}$ = ρ.b.d = 0.00048 ×520×313 = 78.123 mm^2

***Check for $A_{s,min}$.**

$A_{s,min}$is the maximum of :-

$A_{s,min}$ =$0.25\frac{\sqrt{f'_c}}{f_y} b_w.d \geq \frac{1.4}{f_y} b_w.d$

1. **$A_{s,min}$ =**$0.25\frac{\sqrt{24}}{420}\ 120 \times 313 = 109.5\ mm^2$
2. **$A_{s,min}$ =**$\frac{1.4}{420} 120 \times 313 = 125.2\ mm^2\ Control$

$A_{s,required}$= $A_{s,min}$=$125.2\ mm^2$**.**

Use 2ø10, $A_{s,provided}$157.1 mm^2>$A_{s,required}$= 125.2 mm^2.........Ok

S = $\frac{120-40-20-2(10)}{1} = 40\ mm > d_b = 10 > 25\ mm \quad OK$

Check for strain:

a $=\frac{A_{s}.f_y}{0.85 b\, f'_c}=\frac{157.1\times420}{0.85\times520\times24}=6.22\ mm$

c= $\frac{a}{\mathcal{B}_1}=\frac{6.22}{0.85}=7.32mm$

$$\varepsilon_s=0.003\left(\frac{d-c}{c}\right)=0.003\left(\frac{313-7.32}{7.32}\right)=0.125>0.005 \qquad 0k$$

<u>Design of Negtive moment:</u>

M_u = 6.30KN.m

Assume bar diameter ø 12 for main positive reinforcement.

d =h- cover - $d_{stirrups}$ $-\frac{d_b}{2}=350-20-10-\frac{14}{2}=313\ mm.$

R_n $=\frac{M_u}{\emptyset b d^2}=\frac{6.30\times10^6}{0.9\times120\times313^2}=0.595\ Mpa.$

m$=\frac{f_y}{0.85 f'_c}=\frac{420}{0.85\times24}=20.59$

ρ$=\frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right)=\frac{1}{20.59}\left(1-\sqrt{1-\frac{2\times20.59\times0.595}{420}}\right)=0.00144$

$A_{s,req}$ = ρ.b.d = 0.00144 ×120×313= 54.09mm^2

***Check for $A_{s,min}$.**

$A_{s,min}$ is the maximum of :-

$A_{s,min}$ $=0.25\frac{\sqrt{f'_c}}{f_y}b_w.d\geq\frac{1.4}{f_y}b_w.d$

3. **$A_{s,min}$** $=0.25\frac{\sqrt{24}}{420}\,120\times313=109.5\ mm^2$
4. **$A_{s,min}$** $=\frac{1.4}{420}120\times313=125.2mm^2 \quad Control$

$A_{s,required}$=$A_{s,min}$ $=125.2mm^2$

<u>Use 2ø10, $A_{s,provided}$= 157.1 mm^2>$A_{s,required}$= 125.2 mm^2.........Ok</u>

$S = \frac{120-40-20-2(10)}{1} = 40mm > d_b = 10 > 25\ mm \qquad OK$

***Check for strain:**

a $= \frac{A_{s.}f_y}{0.85b\ f'_c} = \frac{157.1\times420}{0.85\times120\times24} = 26.95\ mm$

c$= \frac{a}{\mathcal{B}_1} = \frac{26.95}{0.85} = 31.71mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{313-31.71}{31.71}\right) = 0.936 > 0.005 \qquad 0k$$

✓ **Shear Design for (R9):**

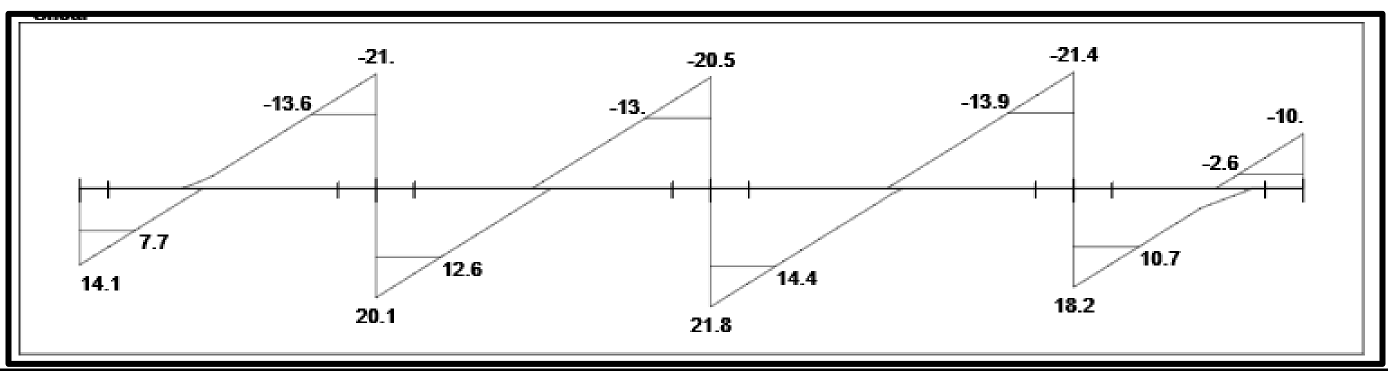


Fig 4.6: **Shear envelop of (R9)**

$V_{u\ max}$ = 13.9 KN

Shear strength V_c, provided by concrete for the joists may be taken 10% greater that for beams. This is mainly due to the interaction between the slab and closely spaced ribs. (ACI, 8.13.8).

$V_c = \frac{1.1}{6}\ \lambda\sqrt{f'_c}b_w d = \frac{1.1}{6}\sqrt{24} \times 120 \times 313 \times 10^{-3} = 33.7\ KN$

Ø* V_c =0.75×33.7 =25.3 KN.

→Check for Cases:-

1- Case 1 : Vu ≤ $\frac{\phi V_c}{2}$.

13.9 **≤ $\frac{25.3}{2}$= 12.56…....Not satisfy**

2- Case 2 : $\frac{\phi V_c}{2}$< Vu ≤ ϕ Vc

12.56 ≤ 13.9≤ 25.3…… satisfy

Minimum shear reinforcement is required except foe concrete joist construction . so no shear reinforcement is provided

4.6 Design of Beam (B25):

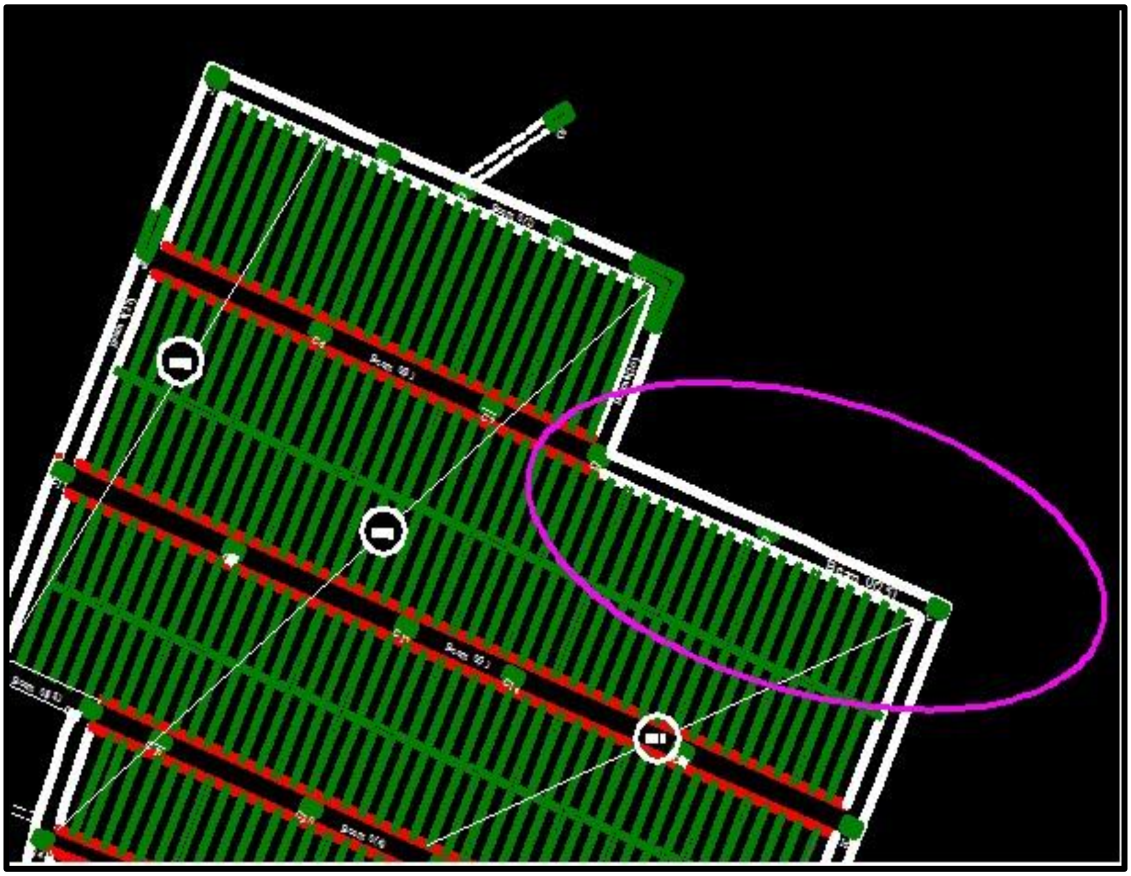


Fig 4.7: **Beam 25**

*Statically system and dimension for B 25

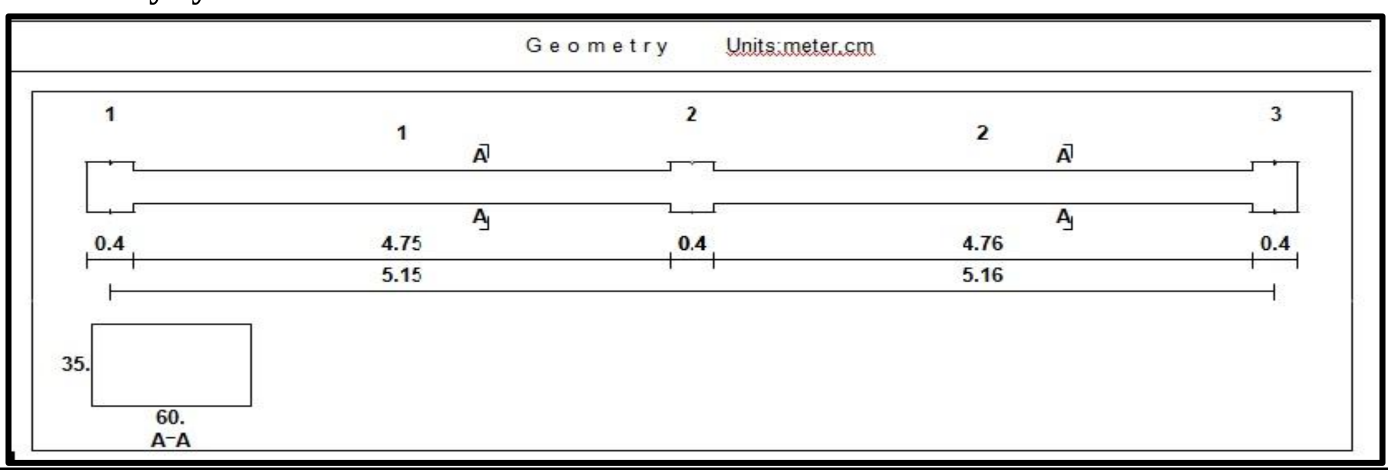


Fig4.8: **Geometry of (B25)**

***Dead load - service**

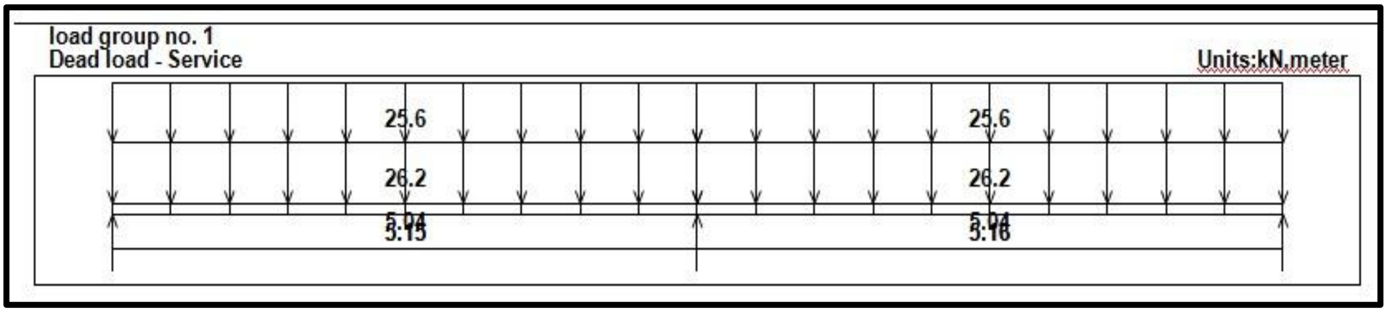


Fig 4.9: Dead load of (B25)

***Live load - service**

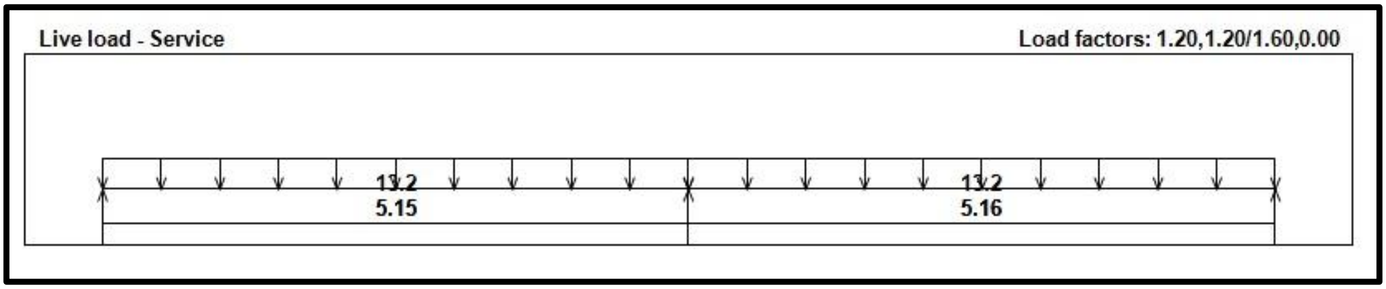


Fig4.10: Live load of (B25)

✓ Flexural Design for (B25):

Moment diagram

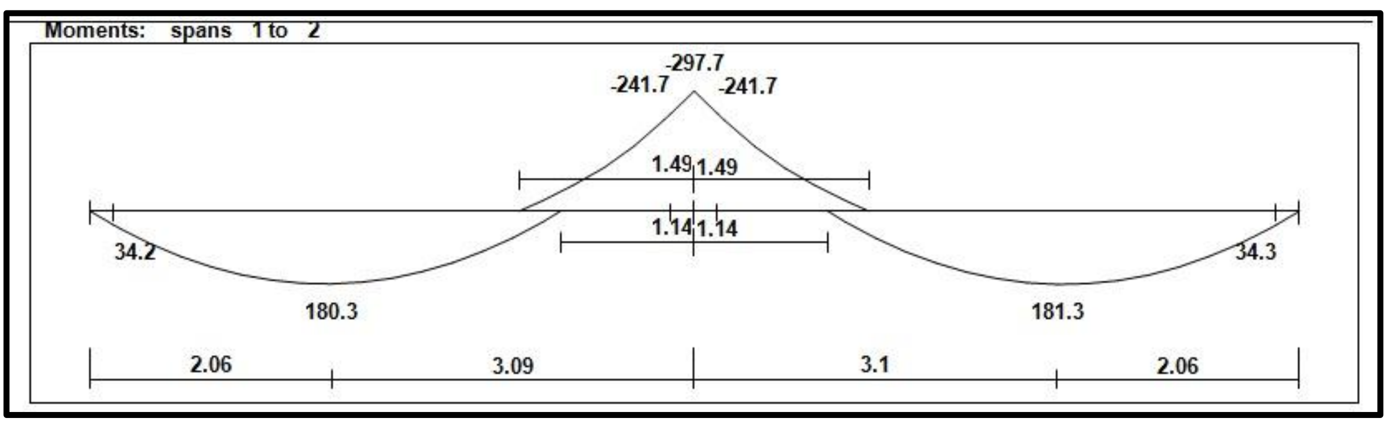


Fig4.11:Moment envelop of (B25)

<u>Design of positive moment for B 25 :</u>

Max positive moment = 181.3KN/m

Assume bar diameter ø 25 for main positive reinforcement.

d =h- cover - $d_{stirrups}$ $-\frac{d_b}{2} = 350 - 40 - 10 - \frac{18}{2} = 291mm$.

Checkif a >h_f to determine whether the section will act as rectangular or T- section,

M_{nf} $=0.85 . f'_c . b . h_f . (d - \frac{h_f}{2})$

$= 0.85 \times 24 \times 600 \times 350 \times \left(291 - \frac{350}{2}\right) \times 10^{-6} = 497KN.m$

M_{nf}≫$\frac{M_u}{\varphi}$=201.5KN.m, the section will be designed as rectangular sectionwith b = 600mm

R_n $= \frac{M_u}{\emptyset b d^2} = \frac{181.3 \times 10^6}{0.9 \times 600 \times 291^2} = 3.96\ Mpa$.

m$= \frac{f_y}{0.85 f'_c} = \frac{420}{0.85 \times 24} = 20.6$

ρ$= \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 3.96}{420}}\right) =.0105$

ρmax=0.85×$\frac{f'_c}{f_y}$×β1 ×$\frac{3}{7}$

ρmax=0.85×$\frac{24}{420}$×0.85 ×$\frac{3}{7}$ = 0.017 >ρreq = 0.0105……design as singly

$A_{s,req}$ = ρ.b.d = 0.0105×600×291 = 1833.3mm^2

***Check for $A_{s,min}$.**

$A_{s,min}$is the maximum of :-

$A_{s,min}$ $=0.25 \frac{\sqrt{f'_c}}{f_y} b_w . d \geq \frac{1.4}{f_y} b_w . d$

4 **$A_{s,min}$** $=0.25 \frac{\sqrt{24}}{420} 600 \times 291 = 509.1mm^2$

5 **$A_{s,min}$** $=\frac{1.4}{420} 600 \times 291 = 582mm^2\ Control$

$A_{s,required}$= 1833.3 mm^2.

Use 8ø18 , $A_{s,provided}$= 2035.7 mm^2>$A_{s,required}$= 1833.3 mm^2. ....Ok

$$S = \frac{600-80-20-(8*18)}{7} = 50.8\ mm > d_b = 18 > 25\ mm \qquad OK$$

Check for strain:

$$a = \frac{A_{s.}f_y}{0.85b\ f'_c} = \frac{2035.7\times420}{0.85\times600\times24} = 69.8\ mm$$

$$c = \frac{a}{\mathcal{B}_1} = \frac{69.8}{0.85} = 82.12mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{291-82.12}{82.12}\right) = .0076 > 0.005 \qquad 0k$$

Max positive moment = 180.3 KN/m

Assume bar diameter ø 18 for main positive reinforcement.

$$d = h - cover - d_{stirrups} - \frac{d_b}{2} = 350-40-10-\frac{18}{2} = 291\ mm.$$

Checkif a >h_f to determine whether the section will act as rectangular or T- section,

$$M_{nf} = 0.85.f'_c.b.h_f.(d-\frac{h_f}{2})$$

$$= 0.85\times24\times600\times350\times\left(291-\frac{350}{2}\right)\times10^{-6} = 496.9\ KN.m$$

$M_{nf} \gg \frac{M_u}{\varphi}$= 200.33KN.m, the section will be designed as rectangular sectionwith b = 600mm

$$R_n = \frac{M_u}{\emptyset bd^2} = \frac{180.3\times10^6}{0.9\times600\times291^2} = 3.9\ Mpa.$$

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

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times3.9}{420}}\right) = 0.0104$$

ρmax=0.85×$\frac{f'_c}{f_y}$×β1 ×$\frac{3}{7}$

ρmax=0.85×$\frac{24}{420}$×0.85 ×$\frac{3}{7}$ = 0.017 >ρreq = 0.0104……design as singly

$A_{s,req}$ = ρ.b.d = 0.0104×600×291 = 1815.84 mm^2

***Check for $A_{s,min}$.**

$A_{s,min}$is the maximum of :-

$A_{s,min} = 0.25\frac{\sqrt{f'_c}}{f_y}b_w.d \geq \frac{1.4}{f_y}b_w.d$

$A_{s,min} = 0.25\frac{\sqrt{24}}{420}600 \times 291 = 509.14mm^2$

$A_{s,min} = \frac{1.4}{420}600 \times 291 = 582mm^2$ ***Control***

$A_{s,required}$= 1815.84mm^2

Use 10ø18, $A_{s,provided}$= 2544.7 mm^2>$A_{s,required}$= 1815.84 mm^2. Ok

$$S = \frac{600-80-20-(10*18)}{9} = 35.6mm > d_b = 18 > 25\ mm \qquad OK$$

***Check for strain:**

$$a = \frac{A_s.f_y}{0.85b\,f'_c} = \frac{2544.7\times420}{0.85\times600\times24} = 87.3\ mm$$

$$c = \frac{a}{\beta_1} = \frac{87.3}{0.85} = 102.7mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{291-102.7}{102.7}\right) = .0055 > 0.005 \qquad 0k$$

<u>Design of Negtive moment:</u>

M_u = 241.7KN.m.

Assume bar diameter ø 18 for main negative reinforcement.

d =h- cover - d$_{stirrups}$ $-\frac{d_b}{2} = 350 - 40 - 10 - \frac{18}{2} = 291\ mm.$

R$_n$= $\frac{M_u}{\emptyset b d^2} = \frac{241.7\times10^6}{0.9\times600\times291^2} = 5.28 Mpa.$

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

ρ= $\frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times5.28}{420}}\right) = 0.014$

$A_{s,req}$ = ρ.b.d = 0.014 ×600×291 = 2444.4mm^2

***Check for $A_{s,min}$.**

$A_{s,min}$is the maximum of :-

$A_{s,min}$ =$0.25\frac{\sqrt{f'_c}}{f_y}b_w.d \geq \frac{1.4}{f_y}b_w.d$

$A_{s,min}$ =$0.25\frac{\sqrt{24}}{420}600\times291 = 509.14mm^2$

$A_{s,min}$ =$\frac{1.4}{420}600\times291 = 582mm^2\ Control$

$A_{s,required}$= 2444.4 mm^2

Use 11ø18 , $A_{s,provided}$= 2799.15 mm^2>$A_{s,required}$= 2444.4 mm^2. Ok

Check for strain:

a =$\frac{A_s.f_y}{0.85b\ f'_c} = \frac{2444.4\times420}{0.85\times600\times24} = 83.9\ mm$

c= $\frac{a}{B_1} = \frac{83.9}{0.85} = 98.7mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{291-98.7}{98.7}\right) = .0055 > 0.005$$

✓ **Shear Design for (B25):**

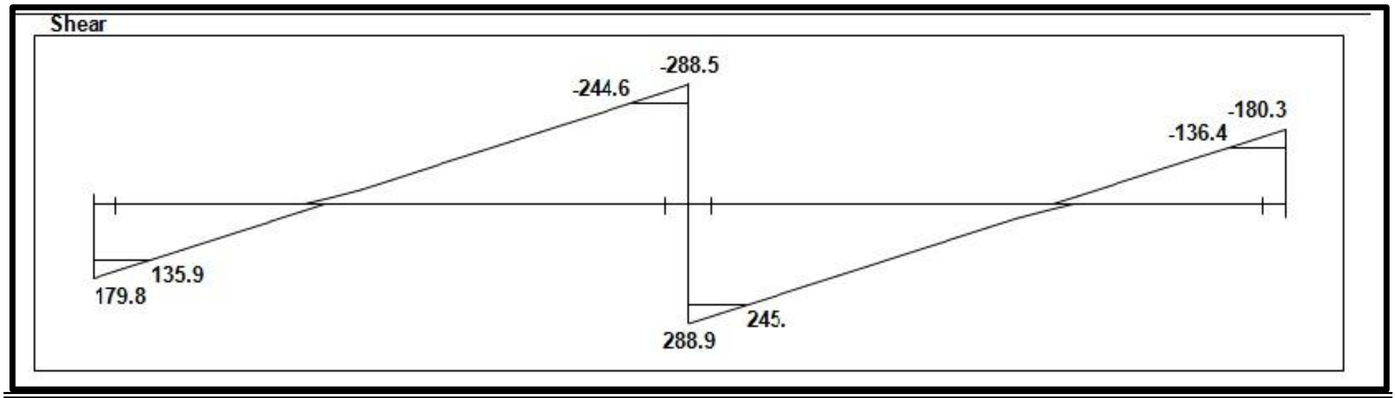


Fig 4.12: Shear envelop of (B25)

$V_{u\,max}$ =245KN

$V_c = \frac{1}{6}\lambda\sqrt{f'_c}b_w d = \frac{1}{6}\sqrt{24} \times 600 \times 291 \times 10^{-3} = 142.6\ KN$

ø V_c =0.75×142.6 =106.95 KN.

→ Check For dimensions:-

$\phi Vc + (\frac{2}{3} * \phi * \sqrt{f'_c} * b_w * d) = 106.95 + (\frac{2}{3} * 0.75 * \sqrt{24} * 600 * 291 * 10^{-3}) =$

=106.95 +427.7 = 534.65KN > Vu = 245 KN Ok

***Check for Cases:-**

1- Case 1 : $Vu \le \frac{\phi V_c}{2}$.

$245 \le \frac{106.95}{2}$= 53.47…....Not satisfy

2- Case 2 : $\frac{\phi V_c}{2} < Vu \le \phi Vc$

53.47≤ 245≤ 106.95……Not satisfy

3- Case3 : $\phi V_c < V_u \le \phi(V_c + V_{s,min})$

Provide minimum shear reinforcement:

$V_{s,min} = \frac{1}{16} * \sqrt{f'_c} * b_w * d = \frac{1}{16} * \sqrt{24} * 600 * 291 * 10^{-3} = 53.46KN.$

$V_{s,min} = \frac{1}{3} * b_w * d = \frac{1}{3} * 600 * 291 * 10^{-3} = 58.2KN$ ………….. control

$\phi V_{s,min} = 0.75 * 58.2 = 43.65KN$

$\phi V_c = 106.95KN < V_u = 245KN \le \phi(V_c + V_{s,min}) = 150.6$……Not satisfy

4- Case 4 : $\phi V_c + \phi V_{s\,min} < V_u \le \phi V_c + (\frac{\phi}{3} * \sqrt{f'_c} * b_w * d)$

$106.95 + 43.65 < 245 \le 106.95 + (\frac{0.75}{3} * \sqrt{24} * 600 * 291 * 10^{-3})$

$150.6 < 245KN \le 320.8KN$…………. satisfy

Design for region 2 and 3 :

$V_{s\,min} = 58.2KN$

Use 4 Leg ϕ 10 for stirrups with $A_v = 314mm^2$

$$s = \frac{Av * fyt * d}{Vsmin} = \frac{314 * 420 * 291}{58.2} * 10^{-3} = 659.4\ mm$$

$s \le \frac{d}{2} = \frac{291}{2} = 145.5$ mm

≤ 600 mm.

$\therefore s = s_{max} = 247.27$ mm

take S= 25 cm

∴ Use Φ10 4legs @ 25 Cm C/C.

4.7 Design of Solid slab:

Slab thickness:

For one end continuous = $\frac{L}{24} = \frac{3.46}{24} = \mathbf{0.144\ m}$

Take h = 15 cm.

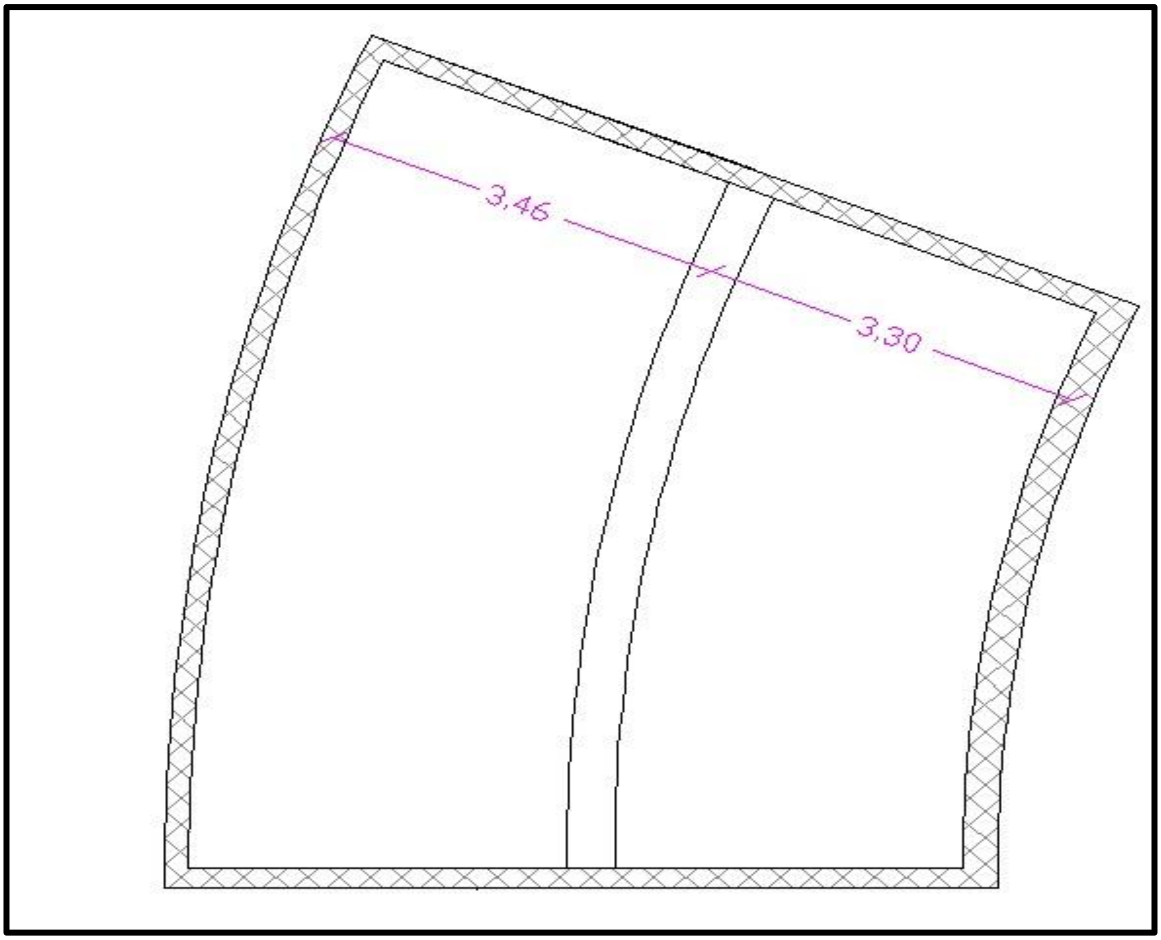


Fig 4.13: Solid Slab

Load calculations:

	γ ×h×1	Load (KN/m)
Tile	0.03×23×1	0.69
mortar	0.03×22×1	0.66
sand	0.07×16×1	1.12
Self weight	0.20×25×1	8.75
	∑	11.22

Live load = 3 KN/m2

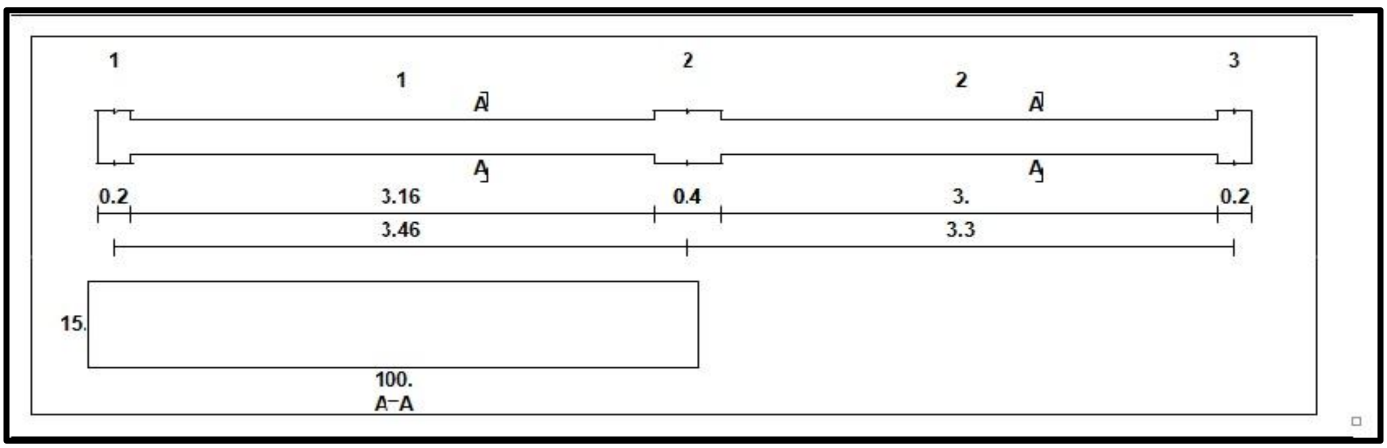


Fig 4.14: geometry of solid slab.

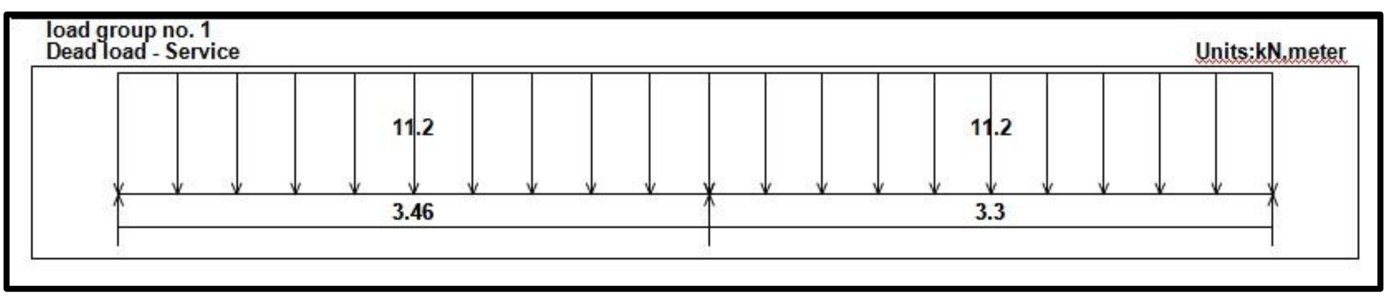


Fig 4.15: load of solid slab.

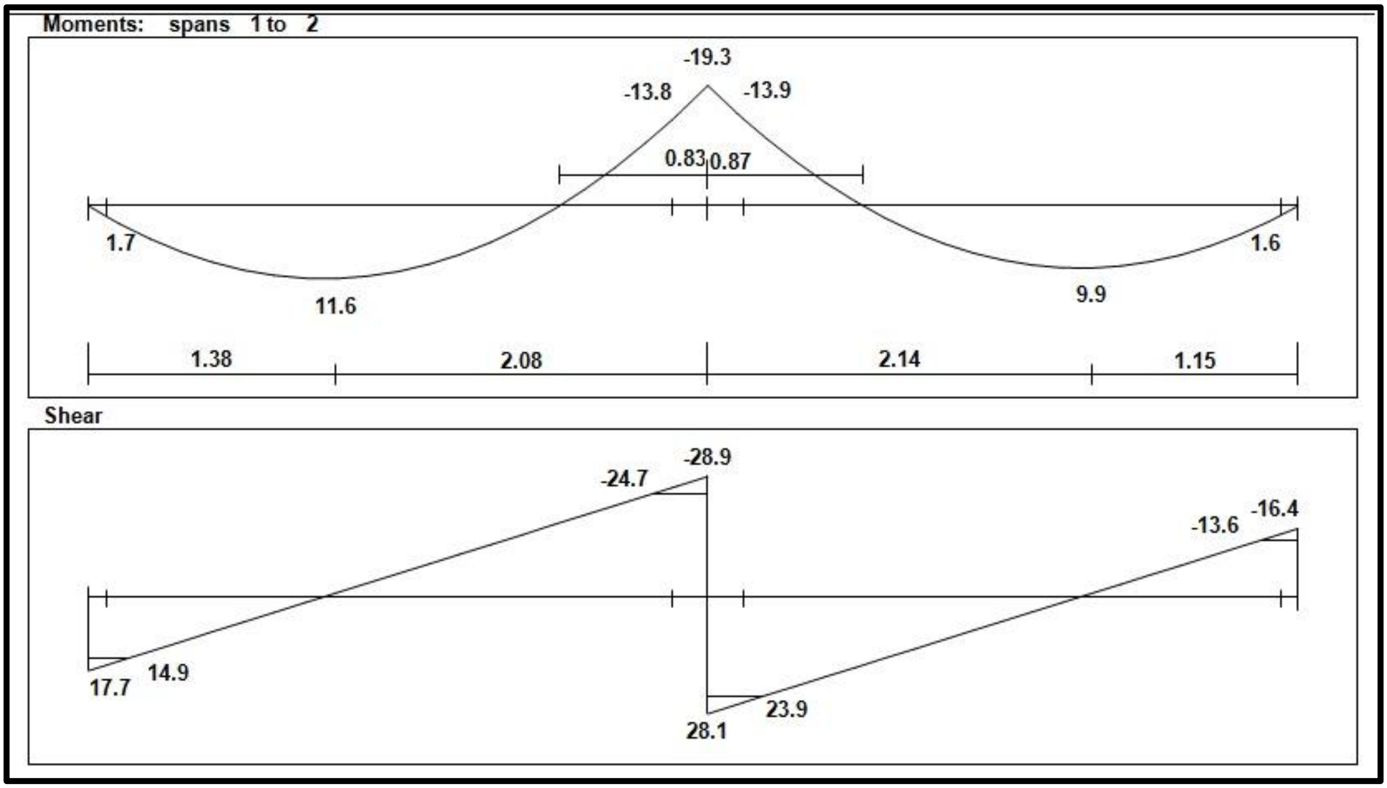


Fig 4.16: envelop moment and shear diagrams of solid slab.

Check whether the thickness of the slab is adequate for shear:

$V_{u,max}$ = 24.7 KN.

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

$V_c = \frac{1}{6}\lambda\sqrt{f'_c} b_w\, d = \frac{1}{6}\sqrt{24} \times 1000 \times 124 = 101.24\ \frac{KN}{1m\ strip}$

$ø\ V_c = 0.75 \times 125.7 = 76\ \frac{KN}{1m\ strip}$

$V_{u,max} < ø\ V_c$

24.7<76 ……..

No need to increase the slab thickness, its adequate enough.

✓ **Design for flexure:**

Design for positive moment:

For M_u =+11.6KN.M

$k_n = \frac{M_u}{\emptyset b d^2}$

$$Kn = \frac{11.6 \times 10^6}{0.9 \times 1000 \times 124^2} = 0.84Mpa$$

m= $\frac{f_y}{0.85 f_c'}$

m= $\frac{420}{0.85 \times 24} = 20.59$

ρ= $\frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right)$

ρ= $\frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2 \times 20.59 \times 0.84}{420}}\right) = 0.002$

A_s = ρ.b.d = $0.002 \times 1000 \times 124 = 248\ mm2$

$A_{s,min}$ = 0.0018× $b \times h$ **=0.0018×** $1000 \times 150 = 270$ **mm^2>$A_{s,req}$**

$n_{\phi 12}$ = $\frac{270}{113} = \frac{3\phi 12}{m\ strip}$ **, ϕ12@200**

As =339.3>270

***Check for the strain:**

a = $\frac{A_{s.}f_y}{0.85 b\ f_c'} = \frac{565.5 \times 420}{0.85 \times 1000 \times 24} = 11.64mm$

c= $\frac{a}{\mathcal{B}_1} = \frac{11.64}{0.85} = 13.69\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{124 - 13.69}{13.69}\right) = 0.024 > 0.005 \qquad 0k$$

Ø=0.9.

For M_u =+9.9 $KN.m$

k_n=0.64Mpa.

ρ = 0.0015

A_s =186 mm^2<$A_{s,min}$.

$n_{\phi 12} = \frac{270}{113} = \frac{3\phi 12}{m\ strip}$, ϕ12@200
As =339.3>270

<u>Design for negative moment:</u>
For M_u = -13.9$KN.m$

k_n=0.9Mpa.

ρ = 0..0022

A_s =272.8 mm^2>$A_{s,min}$.

$n_{\phi 12} = \frac{272.8}{113} = \frac{3\phi 12}{m\ strip}$, ϕ12@200
As =339.3>272.8

<u>*Temperature and shrinkage reinforcement:</u>

$A_{s,min}$ = 270mm^2

$n_{\phi 10} = \frac{270}{78.5} = \frac{4\phi 10}{m\ strip}$, ϕ10@200mm.

4.8 Design column:

PD=500 KN

PL=200 KN

Pu=1.2*500+1.6*200=920 KN

<u>*Check the slenderness effect:</u>

(non sway system)

About X Direction:

Lu=3.5_0.35=3.15m

K=1

r = $\sqrt{\frac{I}{A}} \approx 0.3h = 0.3 \times 0.5 = 0.15$

LX=$\frac{kxL_u}{rx}$= $\frac{1*3.15}{0.15}$ =21

Llimit= $34 - 12\left(\frac{M_1}{M_2}\right)$ $ACI(10.12.2)$

Limit= $34 - 12\left(\frac{1}{1}\right)$=22<40

Lx=21<Llimit=22…….

So the column is short at X.

A bout Y Direction:

Lu=3.5_0.35=3.15m

K=1

r = $\sqrt{\frac{I}{A}} \approx 0.3b = 0.3 \times 0.35 = 0.105$

LY=$\frac{kyL_u}{ry}$= $\frac{1*3.15}{0.105}$ = 30

Ly=30 <Llimit=22…….

So the column is long at Y.

Bressler Equation:

$$\frac{1}{Pn} = \frac{1}{Pnx} + \frac{1}{Pny} - \frac{1}{P0}$$

$$\frac{1}{Pn} = \frac{1}{Pnx}$$

Calculate e_{min} ,M_{min}:

e_{min} =15 +0.03h =15+0.03×350 =25.5 mm.

M_{min}= P_u ×e_{min}=920×0.0255 = 23.46KN.m

$E_c =4700\sqrt{f'_c} = 4700\sqrt{24}$ =23025.2 Mpa.

$I_g = \frac{b.h^3}{12} = \frac{500*.350^3}{12} = 0.1786 \times 10^{10}$ mm^4.

$\beta_{dns} = \frac{1.2*p_d}{P_u} = \frac{1.2*500}{920}$ =0.65<1.

$E.I = \frac{0.4E_c I_g}{1+\beta dns} = \frac{0.4\times 23025.2\times 0.1786* 10^{\wedge}10}{1.65} = 10.07\ KN.m^2$

Determine of Euler buckling load:

$P_c = \frac{\pi^2 EI}{(Kl_u)^2} = \frac{\pi^2\times 10.07}{(3.15)^2} = 10.02\ KN$

Calculate the moment magnifier factor:

$C_m = 0.6 + 0.4\left(\frac{M_1}{M_2}\right) = 1$

$\delta_{ns} = \frac{C_m}{1-\frac{P_u}{0.75P_c}} = \frac{1}{1-\frac{0.920}{0.75\times 10.02}} = 1.14 > 1$

<1.4

The magnified (e) and (M):

$e = \delta_{ns} e_{min}$ =1.14*.0255 =30mm

$M = \delta_{ns} M_{min}$ =1.14*23.46 = 26.7KN.m

From the interaction diagram

$\frac{\gamma}{b} = \frac{350-2*40-2*10-14}{350}$ **=0.67**

$\frac{e}{b} = \frac{0.03}{0.35}$ **= 0.09**

$\frac{\emptyset * pn}{Ag} = \frac{0.920}{0.35*0.5}$ **= 5.26 MN/m^2**

Pn= 5.26*$\frac{145}{1000}$ = 0.76 KSi

$\frac{\gamma}{b}$ **= 0.6 …….. $\rho = 0.01$**

$\frac{\gamma}{b}$ **= 0.67………X**

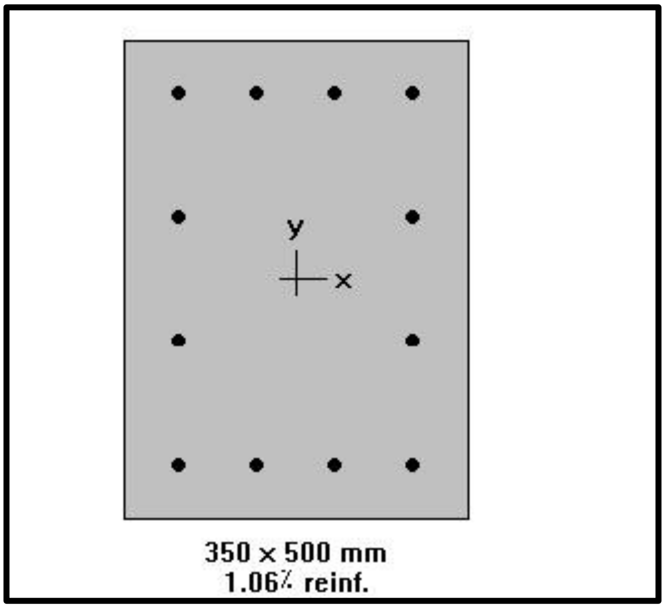
$\frac{\gamma}{b}$ **= 0.75…….. $\rho = 0.015$**

<u>From interpolation :</u>

X= ρ =0.0105

As= ρ*b*h= 0.0105*35*50 =18.3 cm^2

Select 12∅14 … As=18.5 cm^2



<u>Design the stirrups:</u>

The spacing of ties shall not exceed the smallest of:

- **16× d_b = 16×14 =224 mm** **cont.**
- **48×d_s =48 ×10 =480 mm**
- **Least diminution of the column = 350 mm**

Use ϕ10@300mm.

<u>Check for code requirements:</u>

- **clear spacing between longitudinal bars =** $\frac{500-40\times2-10\times2-4*14}{3} = 114.6mm$

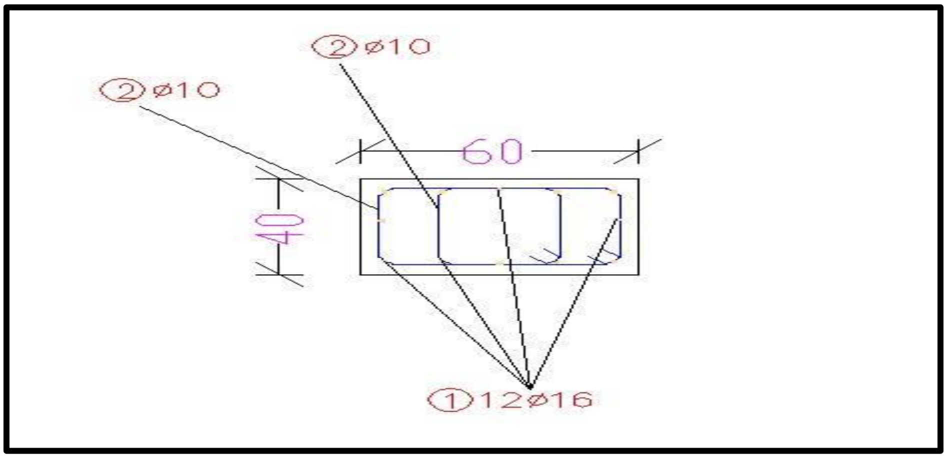
  114.6 mm > 40mm

  >1.5 d_b = 21 mm . **ok**
- **gross reinforcement ratio = 0.0105 ,** **0.01 < 0.0105<0.08** **ok**
- **NO of bars = 12> 4 bars for square columns.**

- min ties diameter :ϕ10 for ϕ32 longitudinal bars and smaller.

<u>Column design:</u>

*** Group ©:- (12Φ16)**



try 100% lap splice:

P= $\frac{2*12*.64}{40*60} = 0.064 < 0.08$

<u>Development length of column reinforcement:</u>

Ldc for Φ 16 :

L_{d} **c** = $\frac{0.24fy}{\sqrt{fc'}}db = \frac{0.24*420}{\sqrt{24}} \times 16 = 330mm$

L_{d} **c=** $0.043 \times db \times fy$ **=0.043×16×420 = 289 mm**

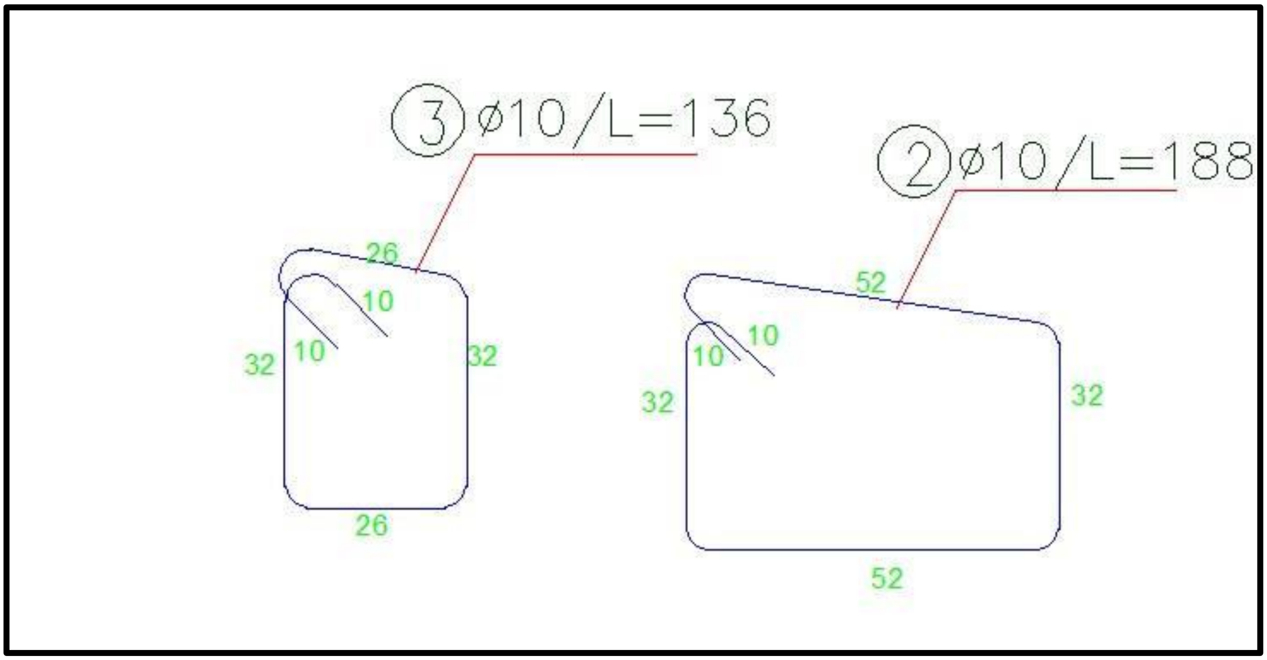
L_{d} **c available=h-cover- Φ1- Φ2= 60-5-1.4-1.4=52.2 cm take it 55cm>33cm ok.**

Dowels length= L_{d} **c ava+Lsc+a=55+90+45=190**

<u>Check space:-</u>

$\frac{40-2*4-2*1-3*1.6}{2} = 12.6cm$

$\frac{60-2*4-2*1-5*1.6}{4} = 10.5cm$



<u>*Development length of closely stirrup:</u>

<u>1-Below Beam:</u>

X=60cm e=12cm

Num of stirrup=(60/12)+1=6

<u>6 Φ10-12cm</u>

<u>2-Lap Splice :</u>

Lsc=0.071*fy*db=0.071*420*16=50cm

Take Lsc=90cm

X=90cm e=10cm

Num of stirrup =(90/10)+1=10

<u>10 Φ10-10cm</u>

<u>3-Normal region:</u>

3.5-.9-.6=2m

X=2m e=20cm

Num of stirrup =(2/0.2)+1 =11

11 Φ10/20cm

4.9 Design of Stairs

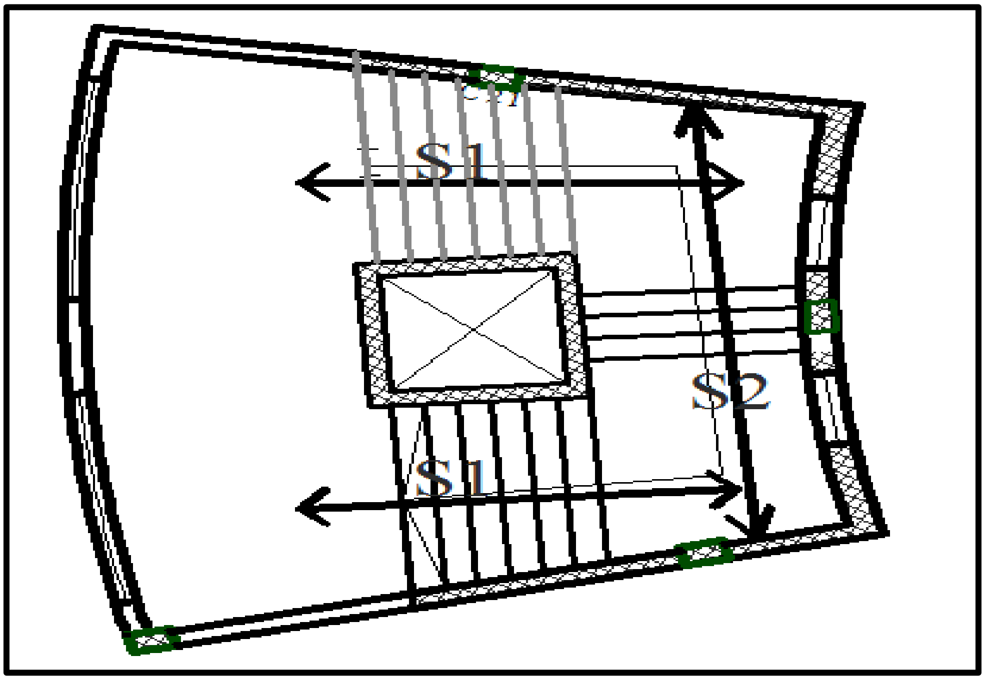


Fig4.17: Stair Plan

Determination of Thickness:

height	rise	run	LL	fc'	fy
3.5m	15 cm	30 cm	5 KN/m2	24 Mpa	420a

***- Minimum slab thickness for deflection is (for simply supported one way solid slab)**

***- h,min = L/ 28**

***- h,min =6.1/ 28 = 21.7 cm ………….take h= 25 cm.**

***- θ = $\tan^{-1}(15 / 30) = 26.56^o$**

Use h = 25cm.

θ=26.56

Load Calculations:

Dead Load calculations of Flight :

$$*Plaster = \frac{0.03 \times 22}{\cos 26.56} = 0.738\ KN/m$$

$$*\text{-}\ concrete = \frac{0.25 \times 25}{\cos 26.56} = 6.99\ KN/m$$

$$*\text{-}\ mortar = \frac{0.3+0.15}{0.3}\ 0.02\ \times 22 = 0.66\ KN/m$$

$$*\text{-}\ stair = \frac{0.3*0.15}{0.3 \times 2}\ 25 = 1.875\ KN/m$$

$$*\text{-}\ Tile = \frac{0.35+0.15}{0.3}\ 0.03\ \times 27 = 1.35\ KN/m$$

Total load (DL) = 11.62 KN/m

Live load (LL) = 4 KN/m

Dead Load calculations of Landing:

material	Gama	h(m)	b(m)	KN/m
Tiles	22	0.03	1	0.66
Mortar	22	0.02	1	0.44
R C	25	0.25	1	6.25
Plaster	22	0.03	1	0.66
Total load(DL)				**8.01**
Live load (LL) = 5 KN/m2				

Table(4-3) calculation of the Dead load for Landing

Total Factored load = 1.2DL + 1.6LL

For W_{flight} , W = 1.2*11.62+ 1.6*4 = 20.34 KN/m

For $W_{landing}$, W = 1.2*8.01+ 1.6*4 = 16.01 KN/m

- <u>Structural System of S1:</u>

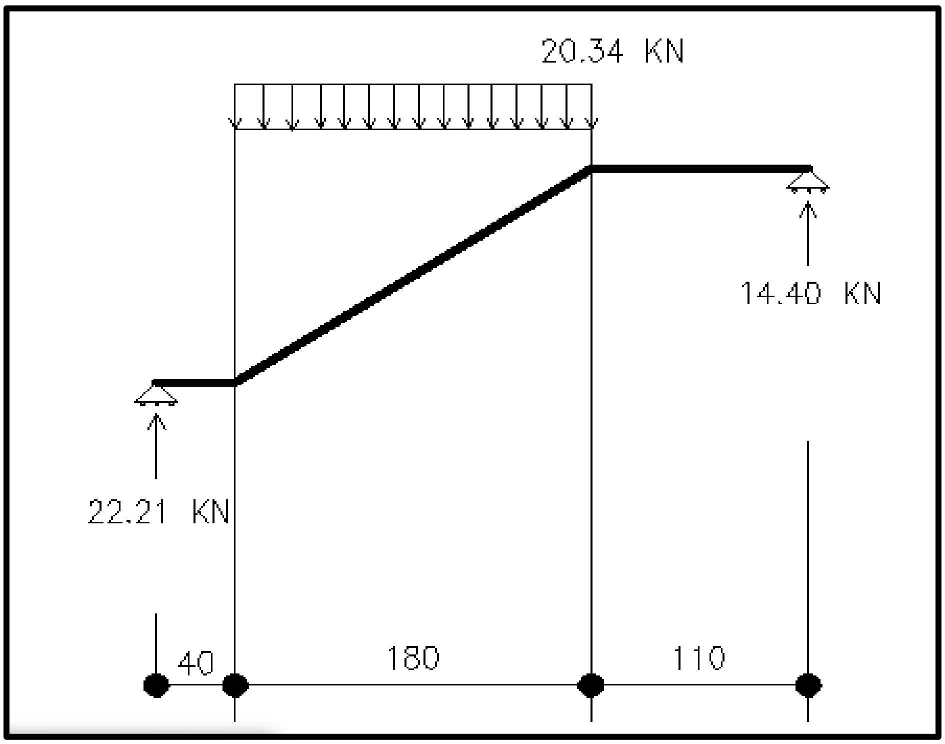


Fig4.18: structural system of S1

<u>Check for shear strength For S1:</u>

Assume Ø 14 for main reinforcement:-

$d = h – 20 – d_b /2 = 250 – 20 – 14/2 = 223$ mm

max shear Vu=22.21 KN

$$\varphi Vc = \frac{0.75 * \sqrt{27} * 1000 * 223}{6} = 144.8 KN/m$$

Vu= 22.21 KN < 0.5* ϕ Vc= 72.4 KN .

Thickness is adequate enough

db (mm)	h(mm)	d (mm)	Vu (KN)	ϕVc (KN)
Ø 14	250	223	22.20	144.8

***Design of Flexure:**

- Design for S1:

Mu = $14.40(1.1+0.9)-20.34*0.9*0.9*0.5=20.56\ \mathrm{KN/m}$

Mn **= Mu / 0.9 = 20.56/ 0.9 = 22.85 KN.m/m**

d = h – 20 – db/2 = 250 – 20 – 14/2 = 223 mm

$$R_n = \frac{Mn}{b \cdot d^2}$$

$$R_n = \frac{22.85*10^6}{1000*223^2} = 0.460\mathrm{MPa.}$$

$$m = \frac{fy}{0.85 \times fc'}$$

$$m = \frac{400}{0.85 \times 420} = 19.66$$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2mR_n}{f_y}}\right) = 19.66\left(1-\sqrt{1-\frac{2*19.66*0.460}{400}}\right) = 0.00116$$

As_{req} **= 0.00116*1000*223 = 259.2 mm2./m <** As_{min} **= 450mm^2/m.... OK**

$$As_{min} = 0.0018*b*h = 0.0018*1000*250 = 450mm^2/m$$

Use Φ 14 then

Mu(KN.m)	m	Rn	ρ	Asreq(mm^2)	Asmin(mm^2)	S(mm)

21.31	**19.66**	**0.476Mpa**	**0.00120**	**268.56**	**450**	**300**

Use Φ 14 @ 300 cm……… As = 462 mm2/m strip.

- Step (s) is the smallest of :-

1. **3*h = 3* 250 = 750 mm**
2. **450 mm**
3. **$\leq 380\ (\frac{280}{fs}) - 2.5 * Cc$**

$\leq 380 * (\frac{280}{\frac{2}{3}f_y}) - 2.5 * 20 = 380 * (\frac{280}{\frac{2}{3} * 400}) - 2.5 * 20 = 399mm$

$\leq 300\ (\frac{280}{fs}) = 300 * (\frac{280}{\frac{2}{3}f_y}) = 300 * (\frac{280}{\frac{2}{3} * 400}) = 210$ mm … (control)

- Check for strain:

Tension = Compression

$$A_S * fy = 0.85 * fc * b * a$$
$$462 * 400 = 0.85 * 25 * 1000 * a$$
$$a = 8.52m$$
$$c = \frac{a}{\beta_1} = \frac{8.52}{0.85} = 10.0mm$$
$$\varepsilon_S = \frac{223 - 10}{10} * 0.003$$
$$\varepsilon_S = 0.06 > 0.005 \longrightarrow ok$$

✓ **Temperature & Shrinkage reinforcement:**

$$As_{Shrinkage} = 0.0018 \times b \times h = 0.0018 \times 1000 \times 250 = 450mm^2/m$$

Use Φ 12 @ 25 cm ……….As prov = 452.5 mm2/m strip

- Step (s) is the smallest of :-

1. 5*h = 5* 250 = 1250 mm

2. 450 mm – control

$As_{Shrinkage}(mm^2)$	S(mm)	db (mm)
452.5	250	Φ 12

Becouse the load on the landing is carried into two direction , only half the load will be considered in each direction 14.40/2=7.20 KN

- Structural System Of S2:

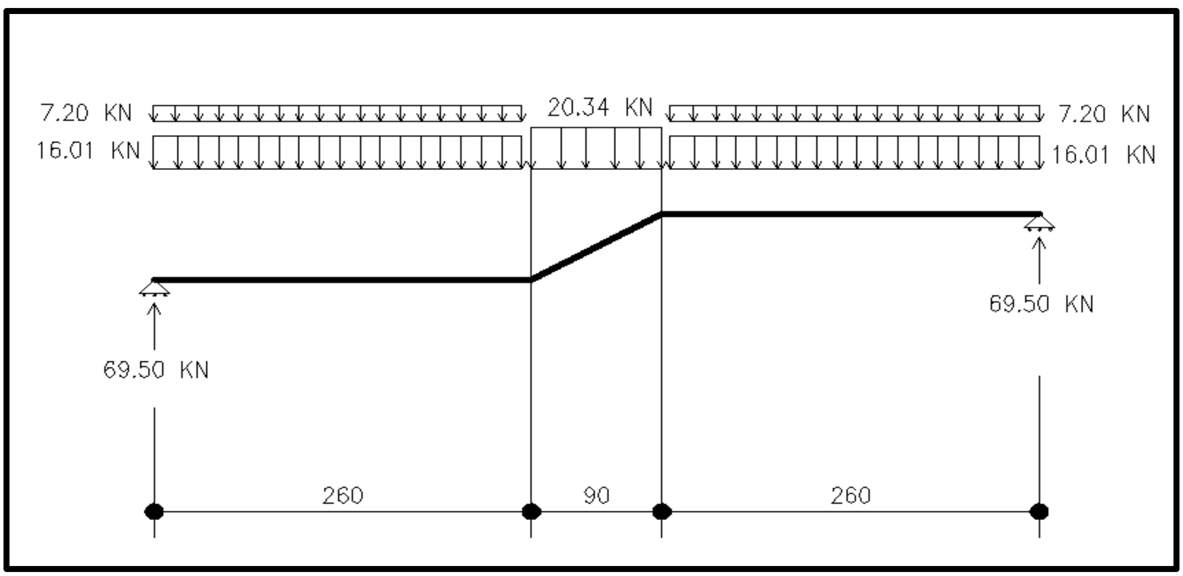


Fig4.19: structural system of S2

Check for shear strength For S2:

Assume Ø 14 for main reinforcement:-

d = h – 20 – db /2 = 250 – 20 – 14/2 = 223 mm

max shear Vu=69.5 KN

$$\phi\,Vc = \frac{0.75*\sqrt{27}*1000*223}{6} = 144.85KN/m$$

Vu= 69.5 KN < 0.5* ϕ Vc= 72.42 KN .

Thickness is adequate enough

db (mm)	h(mm)	d (mm)	Vu (KN)	ϕVc (KN)
Ø 14	250	223	69.5	144.85

Design of Flexure:

- Design for S2:

Mu = $69.5 * 3.05 - 41.63 * 2.2 - 18.72 * 2.2 = 79.21$ KN/m

Mn = Mu / 0.9 = 79.21/ 0.9 = 88.00 KN.m/m

d = h – 20 – db/2 = 250 – 20 – 14/2 = 223 mm

$$R_n = \frac{Mn}{b \cdot d^2}$$

$$R_n = \frac{88*10^6}{1000*223^2} = 1.77MPa\ .$$

$$m = \frac{fy}{0.85 \times fc'}$$

$$m = \frac{400}{0.85 \times 420} = 19.66$$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2mR_n}{f_y}}\right) = \frac{1}{19.66}\left(1-\sqrt{1-\frac{2*19.66*1.77}{400}}\right) = 0.00464$$

As_{req}= 0.00464*1000*223 = 1033.9 mm2./m > As_{min} = 450mm ^{2}/m.... OK

$$As_{min} = 0.0018 * b * h = 0.0018 * 1000 * 250 = 450 mm^2/m$$

Use Φ 14

Mu(KN.m)	m	Rn	ρ	Asreq(mm^2)	Asmin(mm^2)	S(mm)
79.21	19.66	1.77 Mpa	.00464	1033.9	450	150

Use Φ 16 @ 150 cm c/c , As = 1078 mm2/m strip

- Step (s) is the smallest of :-

1. **3*h = 3* 250 = 750 mm**
2. **450 mm**
3. $\le 380 \left(\frac{280}{fs}\right) - 2.5 * Cc$

$\le 380 * \left(\frac{280}{\frac{2}{3} f_y}\right) - 2.5 * 20 = 380 * \left(\frac{280}{\frac{2}{3} * 400}\right) - 2.5 * 20 = 399mm$

$\le 300 \left(\frac{280}{fs}\right) = 300 * \left(\frac{280}{\frac{2}{3} f_y}\right) = 300 * \left(\frac{280}{\frac{2}{3} * 400}\right) = 210$ mm ... (control)

- Check for strain: Tension = Compression

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

$$462 * 400 = 0.85 * 25 * 1000 * a$$

$$a = 8.52m$$

$$c = \frac{a}{\beta_1} = \frac{8.52}{0.85} = 10.0mm$$

$$\varepsilon_s = \frac{223 - 10}{10} * 0.003$$

$$\varepsilon_s = 0.06 > 0.005 \longrightarrow ok$$

- ✓ **Temperature & Shrinkage reinforcement:**

$$As_{Shrinkage} = 0.0018 \times b \times h = 0.0018 \times 1000 \times 250 = 450mm^2/m$$

Use Φ 12 @ 25 cm c/c, As prov = 452.5 mm2/m strip

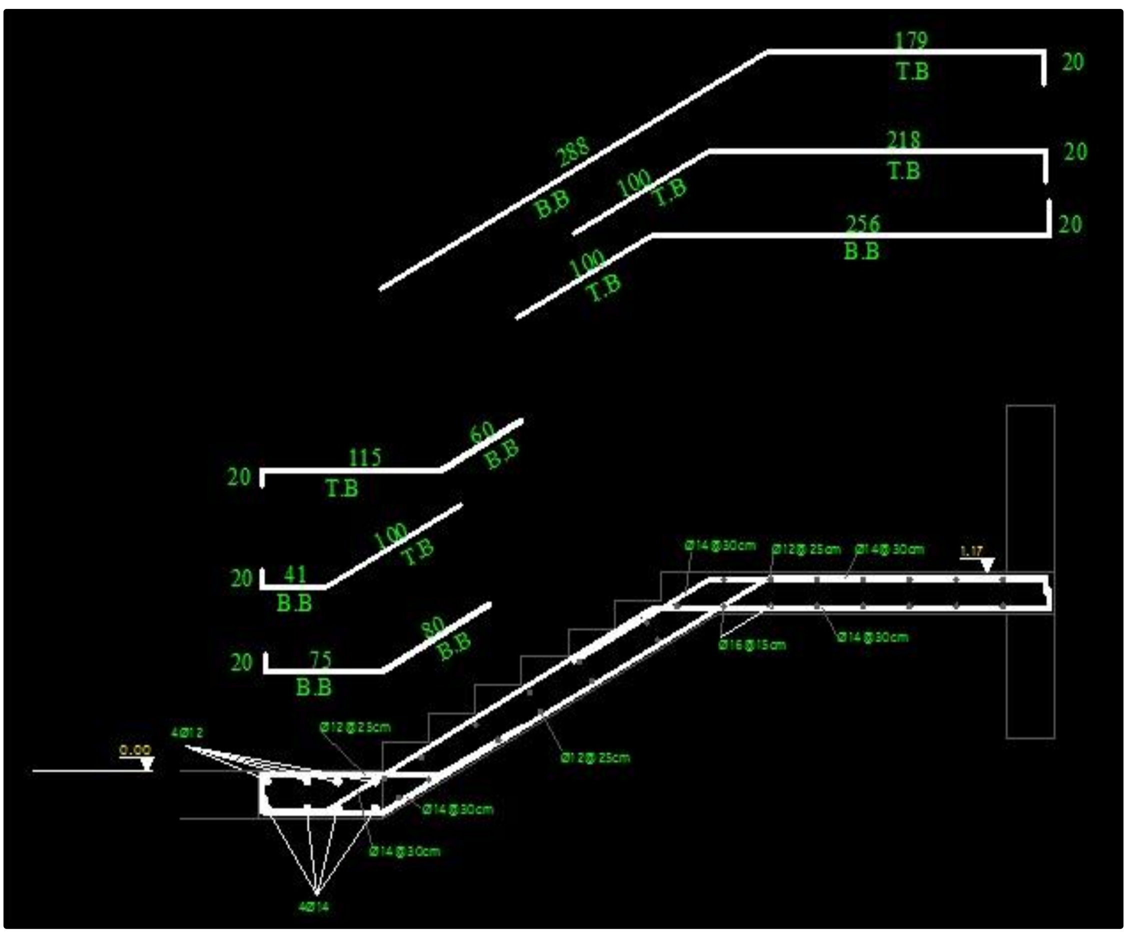


Fig4.20: Reinforcement detail for stairs

4.10 Design of Shear Wall:

*Shear wall (W1) design:

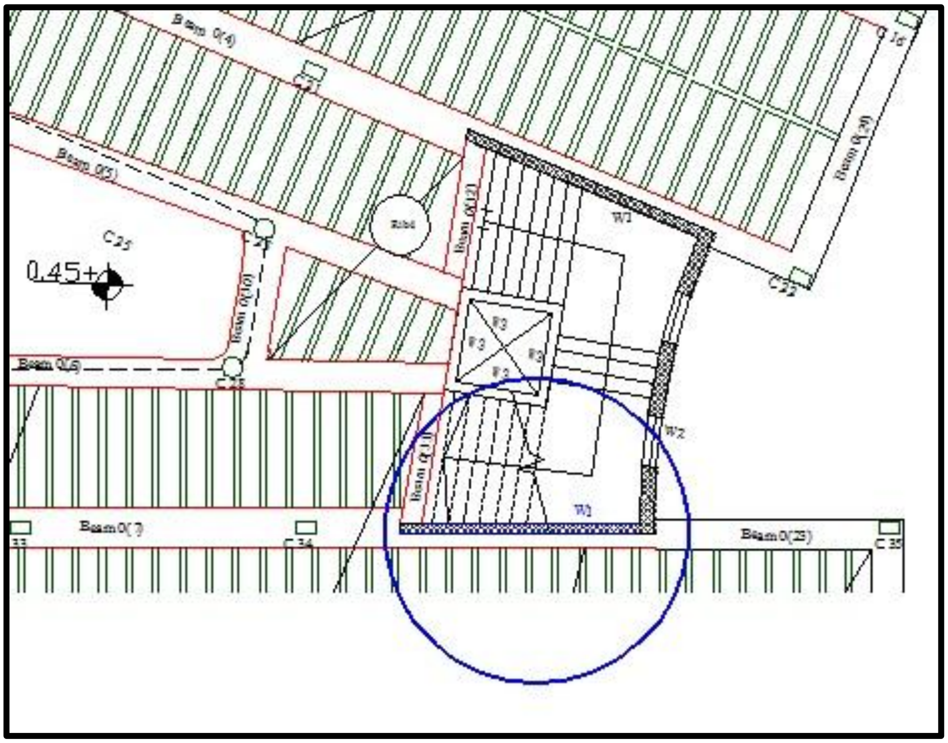


Fig4.21: The Shear Wall

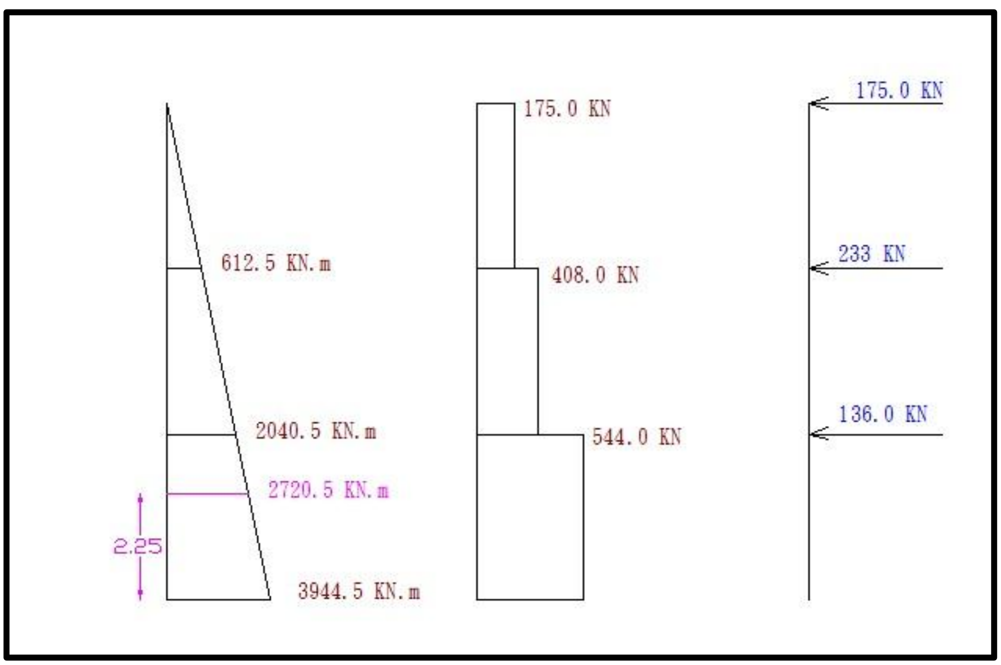


Fig4.22: Moment and Shear for the shear wall

1-Analysis:

***system and internal forces:**

Lw < hw

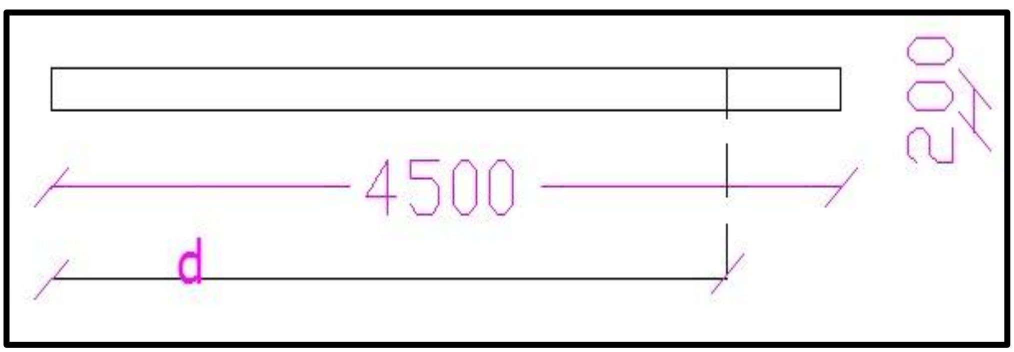
Controlled section for Mu1= $\frac{L_w}{2}$ **from the base .**

Critical section for concrete is the smallest of:

- $\frac{L_w}{2} = \frac{4.5}{2} = 2.25m$ $\quad control.$
- $\frac{\sum h_w}{2} = \frac{10.5}{2} = 5.25m$
- **Story height = 3.5m.**

2-Design :

Design as Rectangular section :



D= 0.8 *Lw= 0.8*4500=3600 mm

***Design of shear force (Horizontal reinforcement Avh):**

Max Vu= 544 KN.

***Shear Strength of concrete Vc:**

V_c is the smallest of :

- $V_c = \frac{1}{6}\sqrt{f'_c} b\, d = \frac{1}{6}\sqrt{24} \times 200 \times 3600 = 587.9KN$, *cont.*

- $V_c = 0.25\sqrt{f'_c}\, b\, d + \frac{N_u . d}{4l_w} = 0.25\sqrt{24} \times 200 \times 3600 + 0.0 = 881.8\ KN$

- $V_c = \left[0.5\sqrt{f'_c} + \frac{L_w\left(\sqrt{f'_c} + 2\frac{N_u}{hl_w}\right)}{\frac{M_u}{V_u} - \frac{L_w}{2}}\right] \frac{hd}{10}$

M_u at critical section =2720.2 KN.m

$$\frac{2720.2}{544} - \frac{4.5}{2} = 2.75036 > 0.0 \quad ok.$$

$$V_c = \left[0.05\sqrt{24} + \frac{4500(0.1\sqrt{24} + 0.0)}{2750.36}\right] 250 \times 3600 = 941.8\ KN$$

Vc=587.9 KN.

ϕ*Vc < Vu

horizontal reinforcement is required .

ϕ*Vc+ ϕ*Vs= Vu

ϕ*Vs = Vu- ϕ*Vc

$$Vs = \frac{Vu}{\phi} - Vc = \frac{544}{0.75} - 587.9 = 137.4\ KN$$

Vs=137.4 KN.

$$\frac{Avh}{S} = \frac{Vs}{fy * d}$$

$$\frac{Avh}{S} = \frac{137.4 * 10^3}{420 * 3600} = 0.09$$

$(\frac{Avh}{s})$min = 0.0025*h= 0.0025*250 = 0.625

$(\frac{Avh}{s})$min=0.625 cont.

max. spacing is the smallest of:

- $\frac{L_w}{5} = \frac{4500}{5} = 900mm$
- 3h = 3*250=750mm.
- 450mm cont.

Avh for two layer of horizontal reinforcement

***Select ϕ10**

Avh=157 mm^2

$\frac{Avh}{s}$ =0.625

Sreq= $\frac{Avh}{0.625} = \frac{157}{0.625}$ = 251.2mm

Select ϕ10@250mm at both side

S=250mm < Smax=450mm

***Design of uniform vertical reinforcement (Avv):**

Avv=0.0025 + 0.5$\left(2.5 - \frac{h_w}{L_w}\right)$ $(\frac{Avh}{s*h}$– 0.0025)*h*s.

Avv=0.0025 + 0.5$\left(2.5 - \frac{10.5}{4.5}\right)$ $(\frac{2*79}{250*250}$– 0.0025)*250 .

$\frac{Avv}{Sv}$= 0.625

Select ϕ10 in two layer:

Avv = 157 mm^2

$\frac{157}{Sv}$ = 0.625

Sv =251.2mm

Select Sv = 250mm< Smax

<u>Smax:</u>

- $\frac{L_w}{3} = \frac{4500}{3} = 1500mm$
- **3h = 3*250= 750m m.**
- **450mm cont**

<u>*Design of Vertical Steel in boundary (Avb):</u>

Mu= Muv+Mub

***part of Muv :**

Asv=157* $\frac{4500}{250}$ **=2826 mm^2**

$\frac{Z}{Lw}$ =($\frac{1}{2+0.85*B1*Fc*Lw*h}$)/(Asv * fy)

$\frac{Z}{Lw}$ =($\frac{1}{2+0.85*0.85*24*4500*250}$)/(2826 * 420) = 0.054

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

Muv = 0.9(0.5*2826*420*4500* ($1 - \frac{0.054}{2}$)) **= 2338.6 KN.M**

Muv<Mu

<u>*Boundary steel is required:</u>

Mub = Mu-Muv

Mub = 3944.5-2338.6 = 1605.9 KN.M

X > $\frac{Lw}{600*(\frac{u}{hw})} = \frac{4500}{600*0.007} = 1070$ **mm.**

LB= length of boundary elements :

LB > $\frac{x}{2} = \frac{1070}{2}$ = 535 mm.

>X-0.1*Lw= 1070-0.1*4500= 620mm.
Select LB= 65 cm

Asb= $\frac{MuB/\phi}{fy(Lw-LB)} = \frac{1605.9/0.9}{420(4500-650)}$ **= 1103.5 mm ^2**

Select ϕ12 @25cm

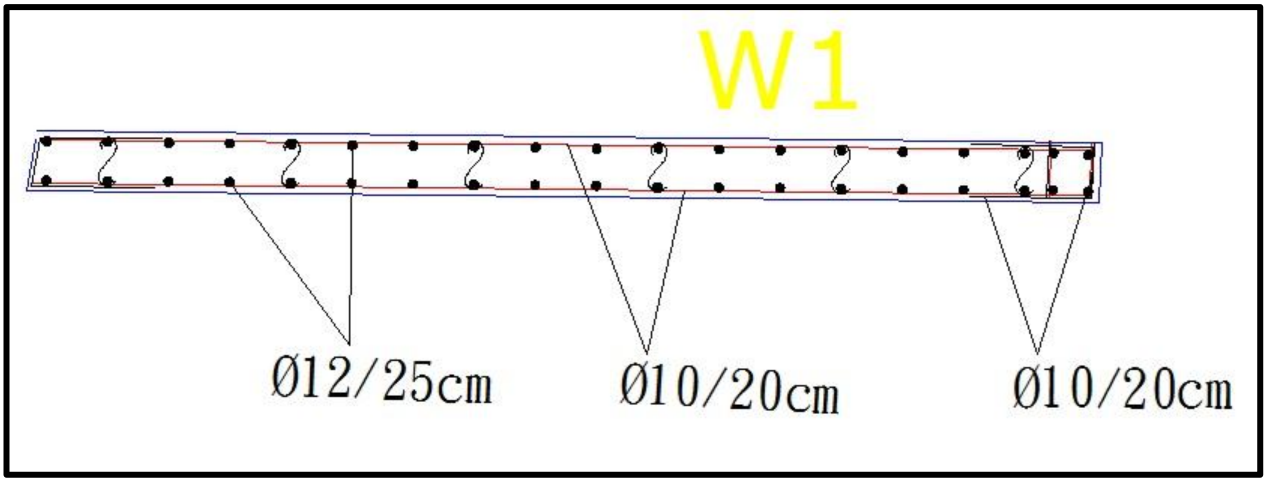


Fig4.23: Reinforcement of Shear wall

4.10 Design of Isolated Footing:

Design of Isolated Footing (FD):

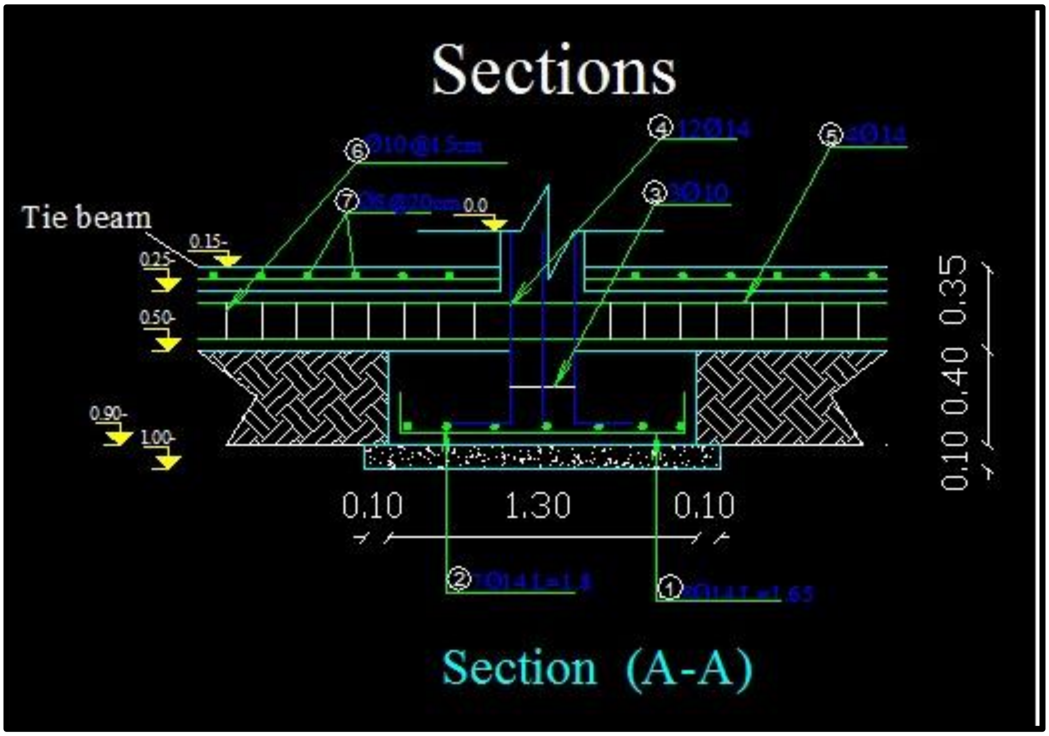


Fig 4.24:detail for the footing

P_D = 500 KN (service).

P_L =200KN (service).

P_U =920 KN (factored).

Column Dimensions A = 35 cm.

B=50 cm.

Allowable bearing capacity Q_{all}= 400 KN/m^2.

Area of Footing:

Soil Density = 18KN/ m ^{3}

live load =5 KN/ m ^{2}.

assume h = 40 cm.

$q_{all \cdot net}$ = 400 - 5 –0.4×25-0 .5×18 = 376 KN/m^2

Area $= \frac{PD+PL}{q_{allnet}} = \frac{500+200}{376} = 1.86$

Use L = 1.45m, B = 1.30 m, A = 1.885 m^2

<u>Depth of footing:</u>

Assume h = 40 cm.

- **<u>Check one-way shear:</u>**

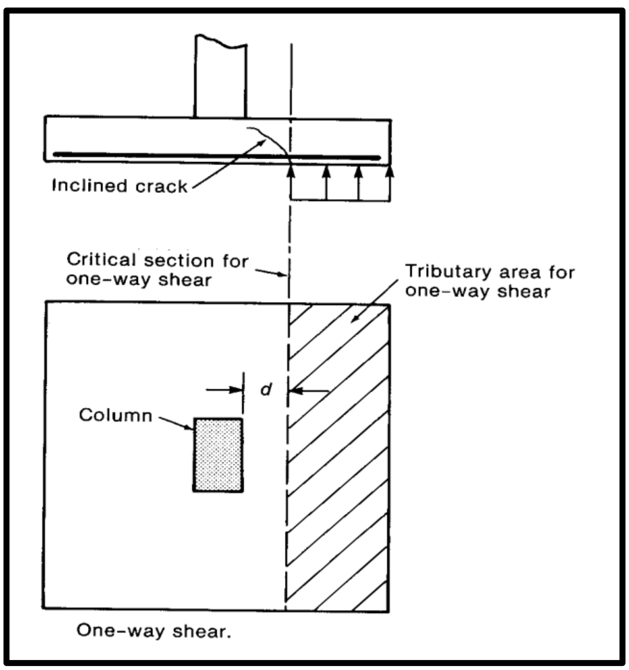


Fig 4.25:one way shear.

$q_{ult} = \frac{P_u}{Area} = \frac{920}{1.885}$ **= 488.06 KN/ m^2.**

d= 400-50-14 = 336 mm

$$\Phi V_c = \Phi \frac{1}{6}\sqrt{f_c{}'}\, b_w d = \frac{0.75}{6} * \sqrt{24} * 1450 * 336 = 298.34KN$$

X= (130/2)- 17.5-33.6 = 13.9 cm

$$Vu = 488.06 * (0.139 * 1.45) = 98.37$$

$øV_c$ =298.34KN > V_{ud} = 98.37 →→→→ $\boldsymbol{ok}$

- **<u>Check two-way shear:</u>**

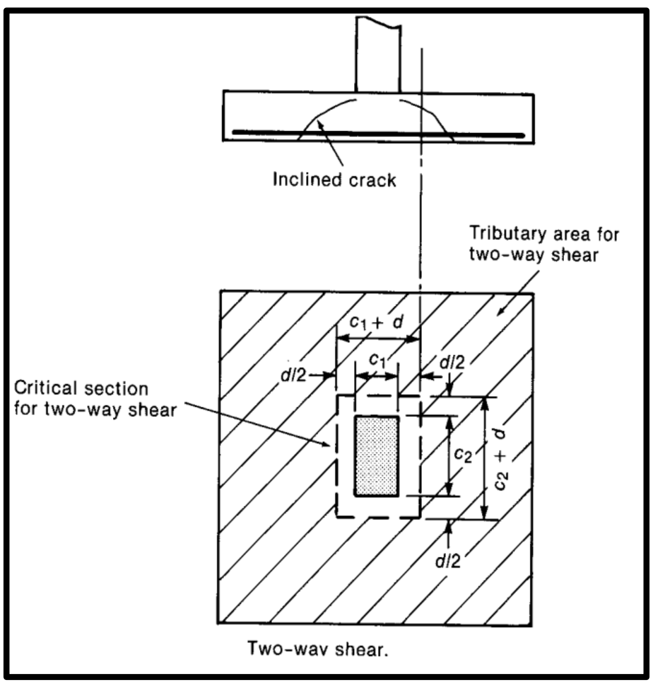


Fig 4.26:two way shear.

$$\frac{d}{2} = \frac{336}{2} = 168mm.$$

To calculate FRb:

35+(d/2)+(d/2)=35+16.8+16.8=68.6cm

50+(d/2)+(d/2)=50+16.8+16.8=83.6cm

FRb=488.06*0.686*0.836=280 KN

V_u = 920-280=640 KN

According to ACI , Vc shall be the smallest of :

$$V_c = \frac{1}{6}\left(1+\frac{2}{\beta_c}\right)\sqrt{f_c'}\,b_o d = 0.5\sqrt{f_c'}\,b_o d$$

$$V_c = \frac{1}{12}\left(\frac{\alpha_s}{b_o/d}+2\right)\sqrt{f_c'}\,b_o d = 0.585\sqrt{f_c'}\,b_o d$$

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

Where:

β_c **= a / b = 50 / 35 = 1.43**

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

= (2*68.6)+(2*83.6)=304.4cm

α_s **= 40 for interior column.**

$$\Phi * V_c = 0.75\times 0.33 * \sqrt{24}\times 3044\times 336 = 1252\bullet 65\text{KN}$$

$$\varphi Vc = 1252.6\ KN > \ Vu\ = 640KN$$

<u>Design of flexural reinforcement:</u>

FRu=488.06*0.475*1.45=336.15 KN

Mu=336.15*0.2375=79.83

Mn = 79.83/0.9= 88.7 KN.m.

Kn = $\frac{Mn}{b*d^2}$

Kn = $\frac{88.7*10^6}{1450*(336)^2}$ **= 0.54 Mpa**

m = $\frac{fy}{0.85*fc'}$ = $\frac{420}{0.85*24}$ **= 20.59**

$\rho = \frac{1}{m}(1 - \sqrt{1-\frac{2mRn}{fy}})$

$\rho = \frac{1}{20.59}(1 - \sqrt{1-\frac{2(20.59)(054)}{420}})$ **=0.0013**

A req = ρ× b × d = 0.0013 × 1450× 336= 633.36mm² .

$A_{s\,min}$ **= 0.0018×1450×400 = 1044 mm² …..control**

So , Use 8 Φ 14with As = 1231.5 mm² > As req =1044 mm²… in both directions .

<u>Development length of flexural reinforcement:</u>

Ld for Φ 14:

$$L_d = \frac{9}{10}\times\frac{fy}{\sqrt{fc'}}\times\frac{\alpha\times\beta\times\gamma\times\lambda}{\left(\frac{k_{tr}+c}{db}\right)}\times db = \frac{9}{10}\times\frac{420}{\sqrt{24}}\times\frac{1\times1\times0.8\times1}{2.5}\times18 = 444.5mm$$

Available length = ((3650-750)\2)-75=1375

= 1375mm > 444.5 mm ……………ok

<u>Design of Compression Lap Splice:</u>

Rec Lsc=0.071*420*14=417.5> min Lsc=300mm.

Choose Lsc=1m >Lsc req

Design Of Compresion development length:

Req Ldc= $0.24\times\frac{420}{\sqrt{24}}\times 14=288mm$

Min Ldc=0.043*420*14=253mm.

Prov Ldc=400-50-2*14=322mm.

Ldc=322mm

<u>Design of Tension development length:</u>

Req Ldt= $(12/25)\times\frac{420}{\sqrt{24}}\times 14=576.2mm$

Prov Ldt=(1300/2)-175-50=425mm

***Req Ldt>Prov Ldt**

Using of 90 deg hokes:

Req ldt*0.7=576.2*0.7=403mm

Hokes=10*db=10*14=140mm