In The Name Of Allah The Merciful

Palestine Polytechnic University

College Of Engineering

Department Of Civil Engineering

Building Engineering

Introduction To The Graduation project

“Structural Design Of Yatta Municipality Building”

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Hebron

Palestine

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Structural Design of Yatta Municipality Building

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Supervisor:

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Abstract:

The main idea of this project is to establish a new municipal building for Yatta municipality, as its current building is old and does not correspond to the increase of departments, employees and residents. Therefore, we worked on preparing the structural designs for this new building, which consists of a Four floors with a total area of 3991 m2, and our goal is to do all Structural designs for all existing structural elements such as slabs, beams, columns, footing, etc.

The Jordanian code for loads has been approved. And the adoption of the American code in various structural designs (**ACI-318-14**). And the adoption of the American code (**ASCE**) for earthquake loads. Analysis and structural design programs have been used, such as (**Atir18**), (**ETABS18**) and (**SAFE**), and other programs such as (**Microsoft office Word, Power Point, Excel, AutoCAD**)

In the end, the necessary executive drawings for all the structural elements were prepared to make it feasible.

التصميم الانشائي لمبنى بلدية يطا

فريق العمل:

عمار محمد ادعيس **محمود أنور راشد**

إشراف :

م.حمدي ادعيس

الملخص:

الفكرة الرئيسية لهذا المشروع هي إنشاء مبنى بلدية جديد لبلدية يطا حيث أن مبناها الحالي قديم ولا يتوافق مع زيادة الأقسام والموظفين والسكان لذا فقد عملنا على عمل إعداد التصاميم الإنشائية لهذا المبنى الجديد الذي يتكون من أربعة طوابق بمساحة إجمالية تبلغ 3991 م2 ، وهدفنا هو عمل كافة التصاميم الإنشائية لجميع العناصر الإنشائية الموجودة من بلاطات وجسور وأعمدة وقواعد وما إلى ذلك.

تم اعتماد الكود الأردني للأحمال. واعتماد الكود الأمريكي في التصاميم الإنشائية المختلفة (ACI-318-14) .واعتماد الكود الأمريكي (IBC2000) بالنسبة لأحمال الزلازل. وقد تم استخدام برامج التحليل والتصميم الإنشائي مثل (Atir18) و (ETABS) و (SAFE).وبرامج أخرى مثل (Microsoft office Word , Power Point , Excel , AutoCAD) وفي النهاية تم إعداد المخططات التنفيذية اللازمة لجميع العناصر الإنشائية ليصبح قابلا للتنفيذ.

DEDICATION

Speech is not sweet except by thanking the one who says:

(وَقُـل رَّبِّ زِدْنِـي عِلْمًـا)

. Glory be to You, my Lord.

To the honest and trustworthy teacher of all humanity and supporter of the oppressed, our intercessor on the Day of Judgment, **Muhammad Bin Abdullah**, may God's prayers and peace be upon him.

He who nurtured me with the light of his heart...and protected me with his wisdom...to the one who gave me drink and fed me, raised me and disciplined me...to the one from whom I learned life lessons...**To my dear father.**

The flower that does not wither...the spring of tenderness...to whom words cannot describe...and the waves of the sea calm down to hear her name...to whom God singled out Paradise under her feet...**To my mother**.

Pure hearts and innocent souls... Earth angels... Anemones... To those who showed me what is beautiful in life... **To my brothers and sisters**.

Those who raised my head high proud of their friendship.. my companions... **To my dear friends.**

Those who raised the flags of knowledge and knowledge and extinguished the flags of ignorance and ignorance, who was the turn?

The greatest in guiding us to the path of knowledge is…….. **To my Honorable teachers.**

ACKNOWLEDGEMENT

This project was a great opportunity to acquire important information and skills in our specialty, and this information was provided to us by people and entities that must be mentioned, praised and thanked.

We would like to express our endless gratitude to everyone who helped us during our project, starting with Palestine Polytechnic University, College of Engineering, Department of Civil and Architectural Engineering for providing us with everything we need to complete the project.

We would like to thank everyone who helped us during our project, and helped us obtain any information that would benefit us in our project.

We would like to sincerely thank our supervisor, **Eng. Hamdi Idas**, who made every effort in encouraging us to do a great job, and providing our team with valuable information and advice to be better every time. Thanks for the constant support and kind communication which makes a huge impact in terms of feeling interested in what we're working on.

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LIST OF ABBREVIATIONS

As	Area Of Non-Prestressed Tension Reinforcement.
As′	Area Of Non-Prestressed Compression Reinforcement.
Ag	Gross Area Of Section.
Av	Area Of Shear Reinforcement Within A Distance (S).
At	Area Of One Leg Of A Closed Stirrup Resisting Tension Within A (S).
b	Width Of Compression Face Of Member.
Bw	Web Width, Or Diameter Of Circular Section.
d	Distance From Extreme Compression Fiber To Centroid Of Tension Reinforcement.
Ec	Modulus Of Elasticity Of Concrete.
Fy	Specified Yield Strength Of Non-Prestressed Reinforcement.
h	Overall Thickness Of Member.
I	Moment Of Inertia Of Section Resisting Externally Applied Factored Loads.
Ln	Length Of Clear Span , Measured Face-To-Face Of Supports In Slabs Without Beams And Face To Face Of Beam Or Other Supports In Other Cases.
M	Bending Moment.
Mu	Factored Moment At Section.
Mn	Nominal Moment.
S	Spacing Of Shear Or In Direction Parallel To Longitudinal Reinforcement.
Vc	Nominal Shear Strength Provided By Concrete.

Vn	Nominal Shear Stress.
Vs	Nominal Shear Strength Provided By Shear Reinforcement.
ρ	Ratio Of Steel Area.
εc	Compression Strain Of Concrete=0.003mm /Mm
Fsd,r	Total Additional Tension Force Above The Support.
Ved,0	Shear Force At Critical Section.
Vu	Factored Shear Force At Section.
Wu	Factored Load Per Unit Length.
Φ	Strength Reduction Factor

Chapter 1

“Introduction”

(1-1) Introduction.

(1-2) Research question.

(1-3) Aims.

(1-4) Objectives.

(1-5) Hypothesis.

(1-6) Methodology.

(1-1) Introduction:

The human being is the main axis around which the various and diverse research and studies revolve, as all these works aim to try to make this person happy and protect him at all levels and levels and work to reduce the risks surrounding him or avoid their effects [1], as these research and projects vary between environmental fields and urban projects and so on [2]. The goal is always the human being, regardless of his geographical location As a result of that, human from his very beginnings has been searching for all the ways and means that help him to facilitate his life and to provide all means in order to reach the comfort and services that would provide the requirements of his life and his needs [3]. With the pursuit of man and his insistence, human has reached the science of engineering [4], and if we discuss in general, we will find that engineering is the body that combines the available technical tools and knowledge activities. It is the professional activity that uses imagination, wisdom and intelligence in the application of science, technology, mathematics and practical experience so that human can Designs, produces, and manages processes that fit human needs [5].

Municipalities, by virtue of their direct interaction with citizens in solving their problems and working to implement the general policy of the state, represent the basis of decentralization and the place of citizens' participation in the conduct of public affairs and popular weight through the elected and enjoy a moral personality and financial independence [6] [7], as the municipalities are considered a part of the state under the supervision of the Ministry of Local Government. The municipality of Yatta is one of the municipalities affiliated to the Ministry of Local Government. It was established in 1966 during the era of the Hashemite Kingdom of Jordan and was at its inception under the name of a village council until 1971 AD, it was upgraded to a municipality. And the municipality of Yatta is classified administratively according to the classifications of local government of local authorities into the classification of the second category (class B), where the municipality of Yatta provides many services to the population [8] [9].

As a result of the population increase in the city of Yatta, which led to an increase in the services provided by the municipality, which led to an increase in the departments that provide various services, which led to overcrowding inside the municipality building due to the small area of the building, which made the municipality's staff to make external expansions and rent buildings that did not meet the required purpose. As the building has become sprawling and does not meet the needs of citizens [10], in this project we designed a new building for the municipality of Yatta capable of accommodating all sections of the municipality under one roof, making it easier for those in charge of the municipality and citizens to complete work and services in a way that allows them to quickly without moving from one building to anothe[11].

In this project, we dealt with the structural design of a new building for the municipality of Yatta, which includes all the service facilities required by any municipal building [12], as the building will accommodate all sections of the municipality under one roof, as attention was paid by the architectural designer when distributing drawers, elevators and vacuum blocks to provide comfort, ease and speed of connection for users And leave us the structural aspect that is our field.

(1-2) Research question:

Is it possible to design or complete this project structurally according to the used codes, methods and programs?

(1-3) Aims:

is to make all the structural designs necessary to make the building safe by using the necessary programs and codes and linking all the information that has been studied to complete the structural design for this project.

(1-4) Objectives:

1. Acquiring the skill in the ability to choose the appropriate structural system for different projects and distributing its structural elements on plans, in proportion to its architectural planning.

2. Proficiency in the use of structural design software.

3. The ability to balance different design methods.

4. Dealing with various problems encountered in the design process.

5. Structural knowledge that enables us to handle various other projects.

(1-5) Hypothesis:

If we use the approved programs, codes, and design parties in a correct order and form, we will arrive at a correct and safe structural design that fulfills the required purpose..

(1-6) Methodology:

In this project, we went through several stages in order to reach the final stage, and the stages were as follow:

1: Project Selection.

1.1: Search for architectural plans.

We went to the Department of Architecture in order to obtain a suitable project, and this process took time and effort until we got to the appropriate project.

1.2: Study the project plan.

At this stage, we studied the architectural plans and identified the architectural elements in order to start the structural design, as studying the project before starting the design process is considered one of the important stages.

2: Structural elements study.

2.1: Study columns.

At this stage, we study the columns that the architect has placed, and if these columns do not affect the structural design, then we adopt these columns, but if there is a structural conflict with the columns, we work after that to change their location in accordance with the structural design

2.2: slabs plans.

At this stage, after making sure of the columns, we determine an initial width of the Beams and draw them on the slabs plans, and we determine a direction, and after that we choose the method of loading that we will adopt for the ribs so that it gives us a safe and economical design, and after that we name the structural elements

3: structural design.

3.1: slabs design.

At this stage of the design, we initially determine the thickness of the Slab, based on the American code ACI318-14, then we design the topping of the slabs, after that we could start designing the ribs on the structural design program (Atir).

3.2: Beams design.

After slab designing, we could take the reactions of the ribs supports to carry the loadings of the ribs on the beams to start the beam designing by the structural design program (Atir).

3.3: columns design.

Now after designing the ribs and the beams, I can design the columns after carrying the loads of the beams.

3.4: walls design.

At this stage of the design, we design all the shear walls in the plan, which come in the basement walls, staircase walls, and elevator walls, and the design is according to the American code ACI318-14.

3.5: Foundations design

The foundations are designed at the end after designing all the structural members of the building and after calculating the loads on the foundations.

4: Finishing the project.

4.1: Preparing the final blueprints.

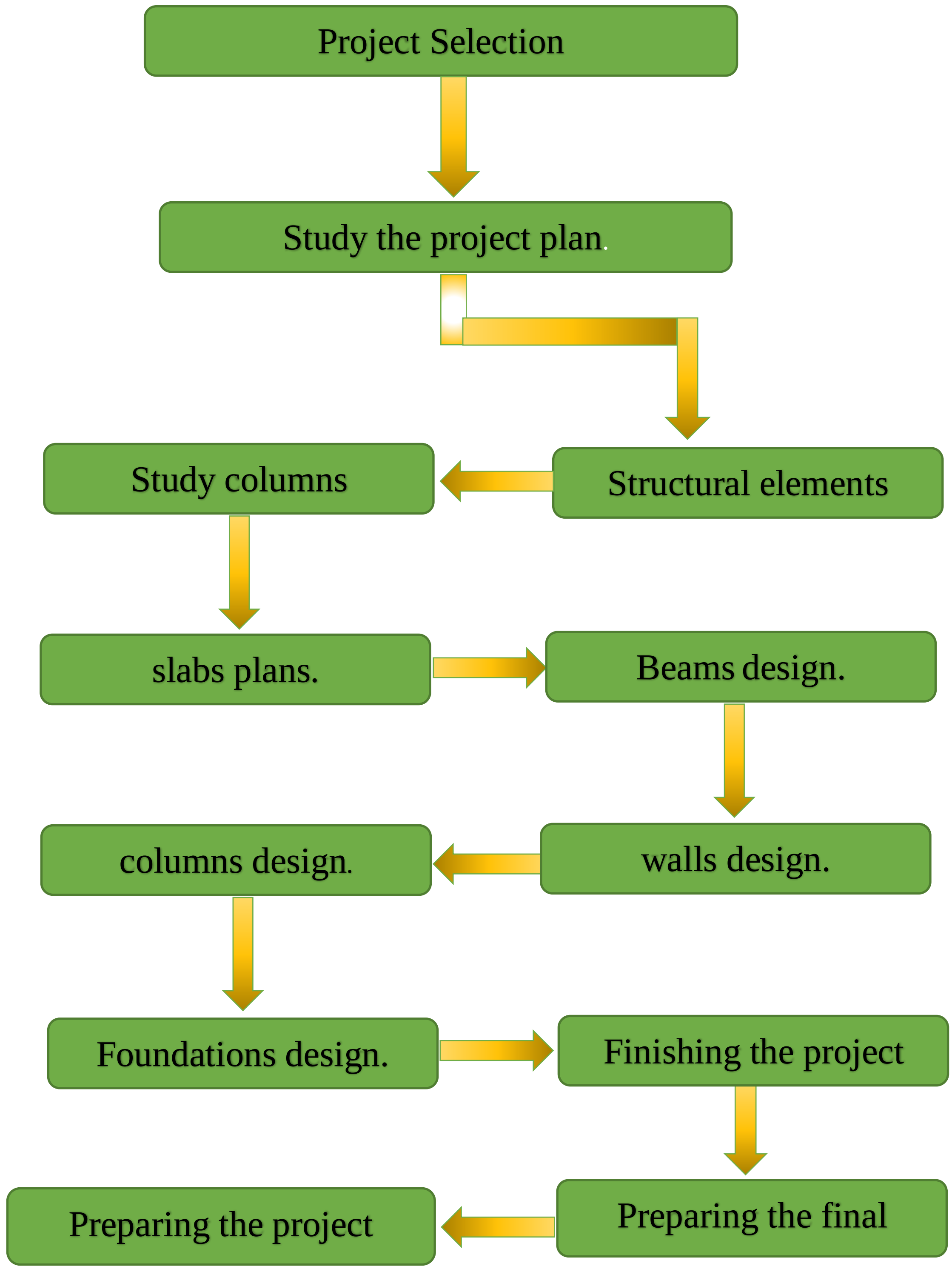
After completing the structural design process, we prepare the plans for all the architectural and construction elements, as each element must have a plan to study each element separately during the implementation process.

4.2: Preparing the project book.

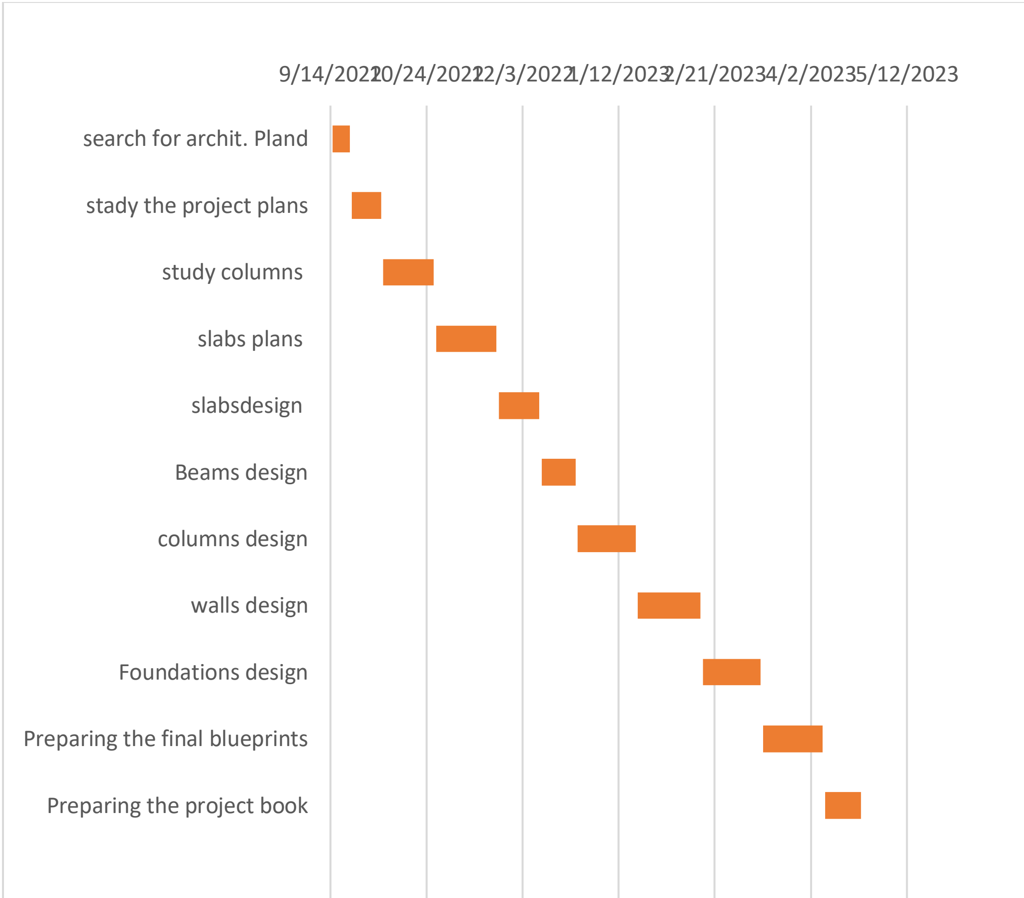
Where the project book contains an explanation that explains the constituent elements of the project and also explains the mechanism of work in the project until reaching the end of the project.

Section	Activity	D.Start	Duration	D.Finish
1	Project Selection.	15/9/2022	20 days	5/10/2022
1.1	Search for architectural plans.	15/9/2022	7 days	22/9/2022
1.2	Study the project plan.	23/9/2022	13 days	5/10/2022
2	Structural elements study.	6/10/2022	44 days	22/11/2022
2.1	Study columns.	6/10/2022	21 days	27/10/2022
2.2	slabs plans.	28/10/2022	23 days	22/11/2022
3	structural design.	23/11/2022	106 days	12/3/2023
3.1	slabs design.	23/11/2022	17 days	10/12/2022
3.2	Beams design.	11/12/2022	15 days	25/12/2022
3.3	columns design.	26/12/2023	23 days	19/1/2023
3.4	walls design.	20/1/2023	25 days	15/2/2023
3.5	Foundations design.	16/2/2023	26 days	12/3/2023
4	Finishing the project.	13/3/2023	40 days	23/4/2023
4.1	Preparing the final blueprints.	13/3/2023	25 days	7/4/2023
4.2	Preparing the project book.	8/4/2023	15 days	23/4/2023

Table (1-1): Timetable for the project



Figure(1-1):Methodology for the project.



Figure(1-2): Timetable for the project.

Chapter 2

“Architectural Description”

(2-1) An overview of the project.

(2-2) project Location.

(2-3) importance of the site.

(2-4) Movement of the sun and wind.

(2-5) Humidity.

(2-6) Description of the project floors.

(2-7) Elevations.

(2-8) Longitudinal sections.

(2-9) Description of movement and entrances.

(2-1) An overview of the project:

The city of Yatta is one of the Palestinian cities located in the West Bank, 12 km from the city of Hebron in the south, and about 60 km from the city of Jerusalem, and today it is considered one of the largest cities in terms of population. One of the most important problems facing the Palestinian cities in general and the city of Yatta in particular is the Israeli occupation's control over a percentage of the available lands and resources and their scarcity at the same time, and the absence of good planning in distribution. of homes and buildings.

With the economic and social development and population increase in the city of Yatta, there was a need to initiate a design proposal for a new building for the municipality of Yatta, in order to meet all the services needed by the citizens.

This proposed design is designed to facilitate the movement of citizens and employees on the level of the project floors, in addition to easy access to the parking .

Where the project consists of three floors addition to the ground floor, where the total area of the building is estimated at (3991 m^2) square meters, and it also contains a garden and car park. Figure (2-1) shows the general location of the project.

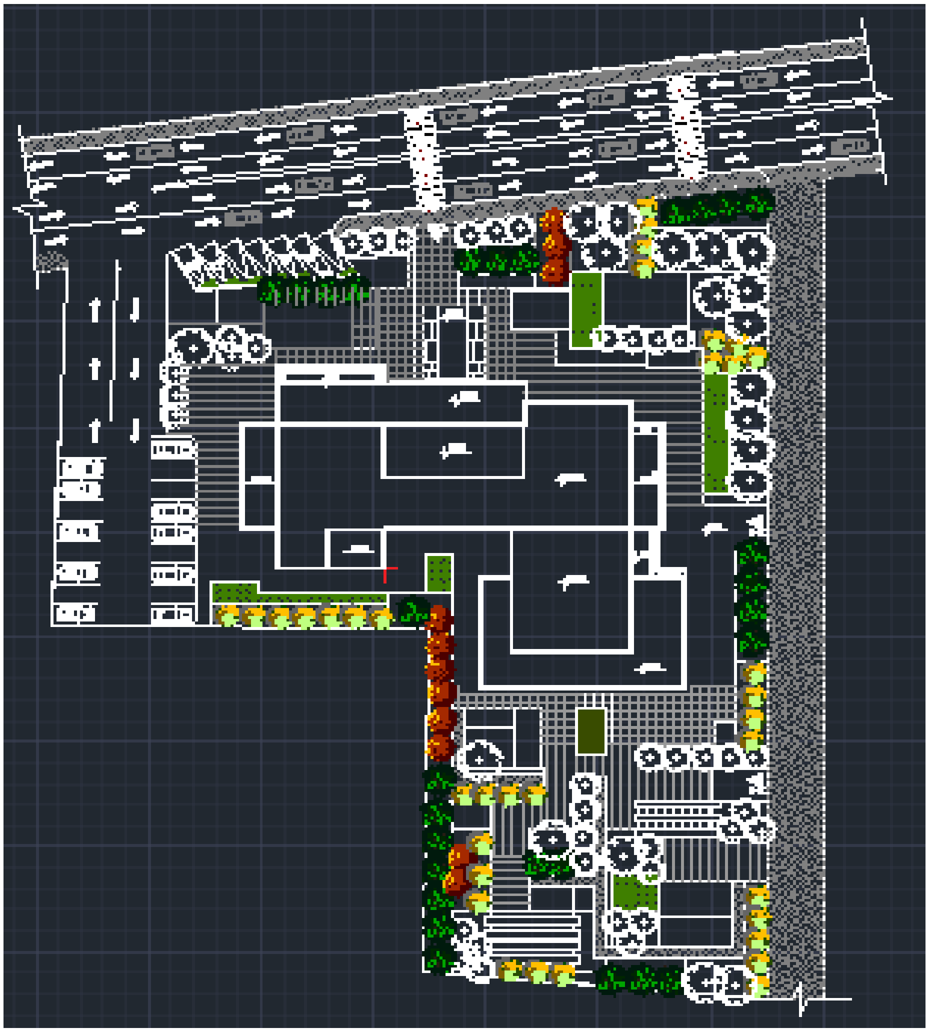


Figure (2-1): general location of the project.

(2-2) project Location:

The proposed plot of land is located in the southeastern side of the city of Yatta near the Yatta International Stadium in Futuh area, where the average elevation of the city above sea level is 820 meters. The following figure (2-2) shows the location of the plot of land.

Figure (2-2) A picture showing the location of the plot of land.

(2-3) importance of the site:

There are foundations and criteria that help in making a decision that takes the project towards integration and compatibility with the general urban fabric. The following are several important points in the site selection process:

- Geography of the site: It is the aspect that specializes in studying the location of the land in relation to the urban fabric in general, and the impact of the site on the function of the building, and the study of the climate and topography of the land.
- Transportation network: The building is easily accessible from roads and transportation.
- Vegetation: It is the aspect that talks about the nature of the land in terms of vegetation, including trees and plants.
- Patterns and types of surrounding buildings: commercial, industrial, residential, or service, and how these buildings affect the plot of land and their impact on the building to be built.

(2-4) Movement of the sun and wind:

The city of Yatta is exposed to southwesterly winds that bring rain and lower the temperature in the highlands. It is also exposed to cold eastern winds in winter, and dry winds such as the Khamaseen winds blow in late spring.

Studying the movement of the sun and the wind is one of the important factors in analyzing the building, because the sun is a desirable energy, and directing the building towards the sun while protecting it from the brightness that falls on it from the western region is a successful way to obtain the largest possible amount of solar energy in cold days, and reduce the amount of energy consuming heating, and the wind has a great impact on buildings, as it is considered a horizontal load that affects the walls of the building, and therefore on its structural structure, so the effect of wind and sun on the building must be taken into account in order to be designed in a way that meets the design requirements related to ventilation.

(2-5) Humidity:

The average humidity in Yatta town ranges between 43-67% in the winter season. The city's elevation above sea level reduces the moisture content of the air coming from the sea. Yatta is located at an altitude of 850 meters above sea level.

(2-6) Description of the project floors:

Where the project consists of three floors in addition to the ground floor and the basement.

(2-6-1) Ground Floor:

Its level is (0.00 m) and an area estimated at (1123.62 m^2) .

The ground floor consists of the entrance foyer and contains the theatre, rooms belonging to the theatre, bathrooms belonging to the theatre, dining hall, customer waiting area, public bathrooms, kitchen and staff offices. It also contains many elevators and stairs to facilitate the movement of employees and customers. As shown in the following figure (2-3).

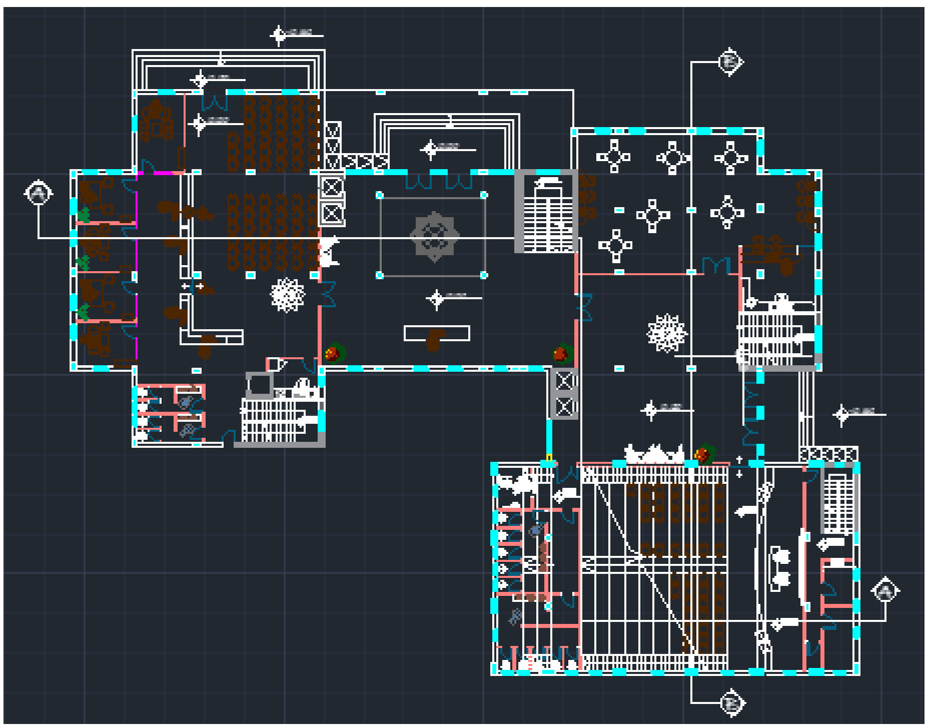


Figure (2-3):Ground floor.

(2-6-2) First Floor:

Its level is (+4.00 m) and an area estimated at (1202.41 m^2) .

The first floor consists of several administrative departments, including the Department of Engineering, Projects and Roads. It contains a room for the director and offices for workers, the computer department, the health department, and it contains a place for prayer, and a part of the theater , Public bathrooms, stairs and elevators It also contains a skylight. As shown in the following figure (2-4).

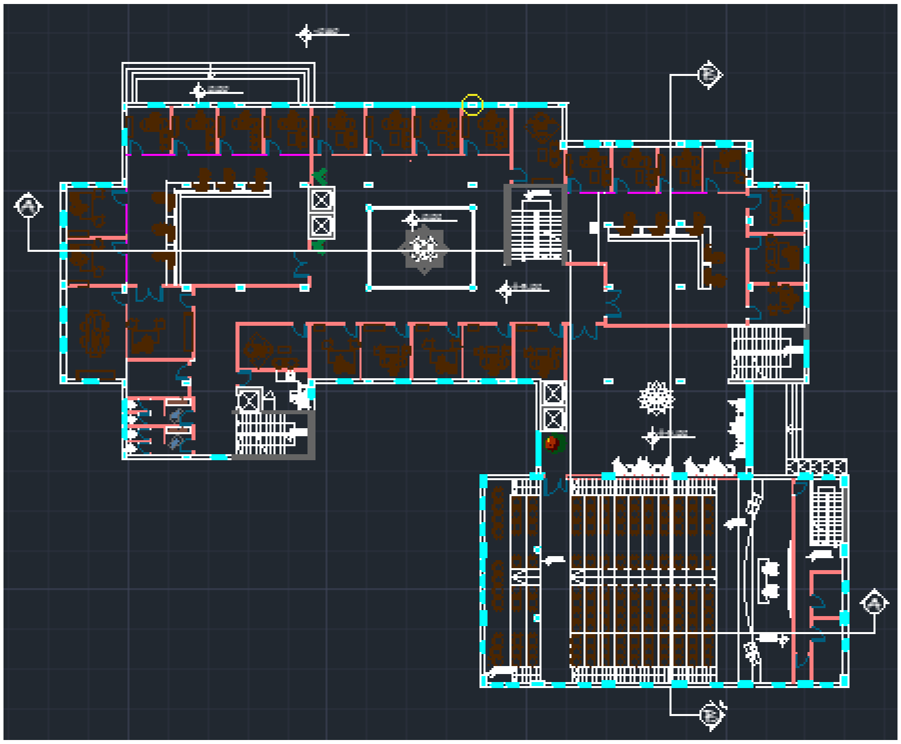


Figure (2-4):First floor.

(2-6-3) Second Floor:

Its level is (+8.00 m) and an area estimated at (1078.38 m^2) .

The second floor consists of a number of administrative departments, the financial department, the electricity department, offices for employees, a meeting room, a room for the manager, public bathrooms, a number of stairs and elevators, and it also contains a skylight. . As shown in the following figure (2-5).

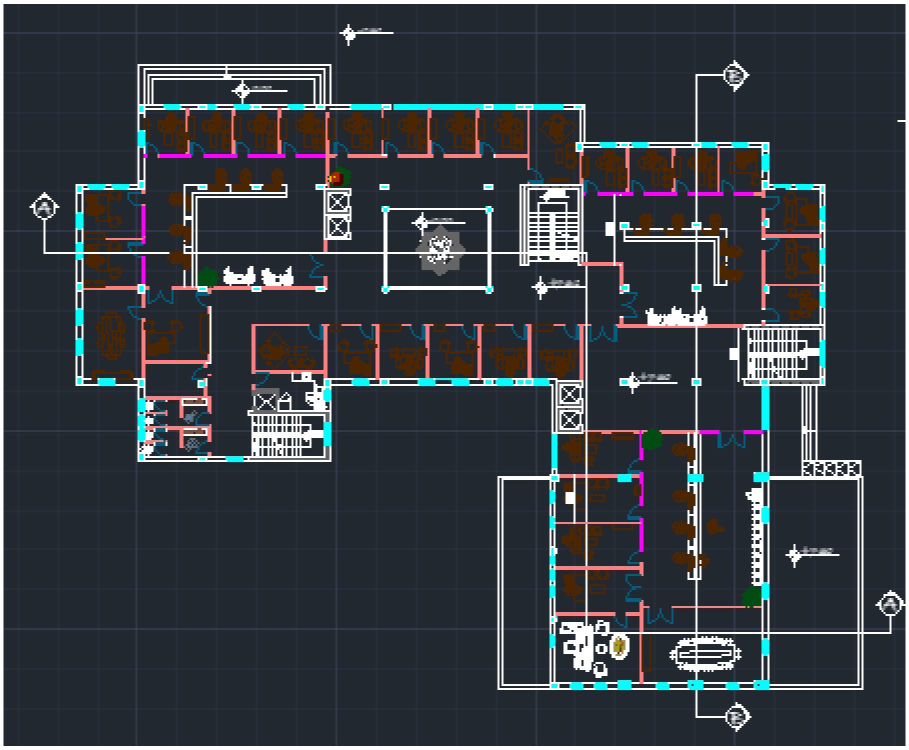


Figure (2-5):Second floor.

(2-6-4) Third Floor:

Its level is (+12.00 m) and an area estimated at (586.67 m^2) .

The third floor contains the office of the mayor, a room for the secretary, an office for the advisor, a room for the director, meeting rooms, a room for members of the municipal council, public bathrooms, and a private bathroom for the president. It also contains a kitchen, stairs and elevators, and a skylight. As shown in the following figure (2-6).

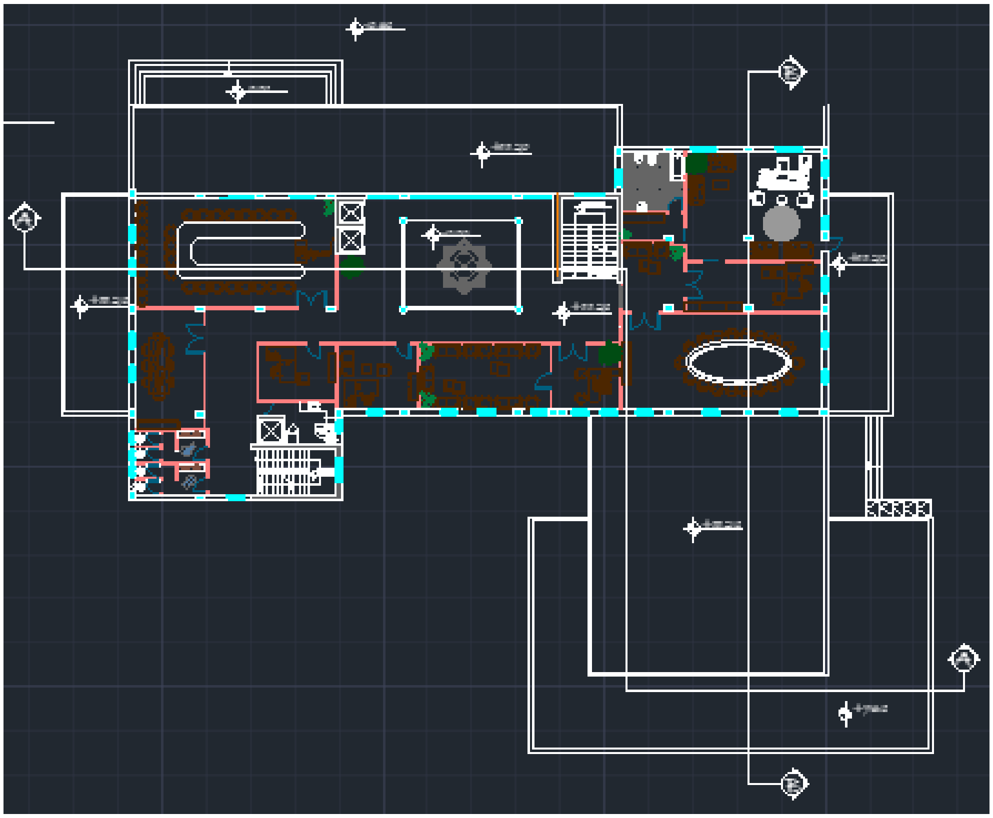


Figure (2-6):Third floor.

(2-6) Elevations:

(2-7-1) Northern Elevation:

It contains the main entrance to the building as well as another secondary entrance. This Elevation shows the floors of the building, and it contains various structural elements represented by stone, glass and aluminium, as this diversity gives the building a special aesthetic. As shown in the following figure (2-7).

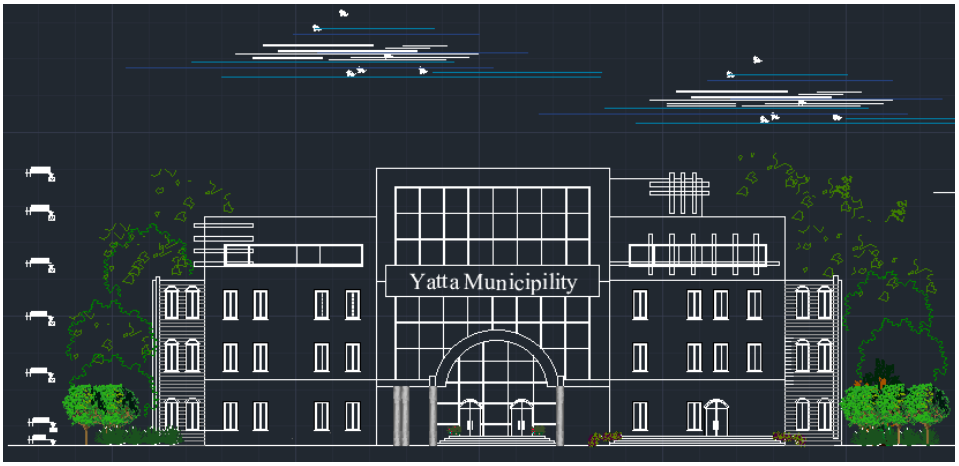


Figure (2-7):Northern Elevation.

(2-7-2) Eastern Elevation:

This Elevation contains a sub-entrance to the municipality, and this entrance is adjacent to the theater, and the distribution of openings appears in a beautiful civilized styles and It shows the staircase that runs through all floors. As shown in the following figure (2-8).

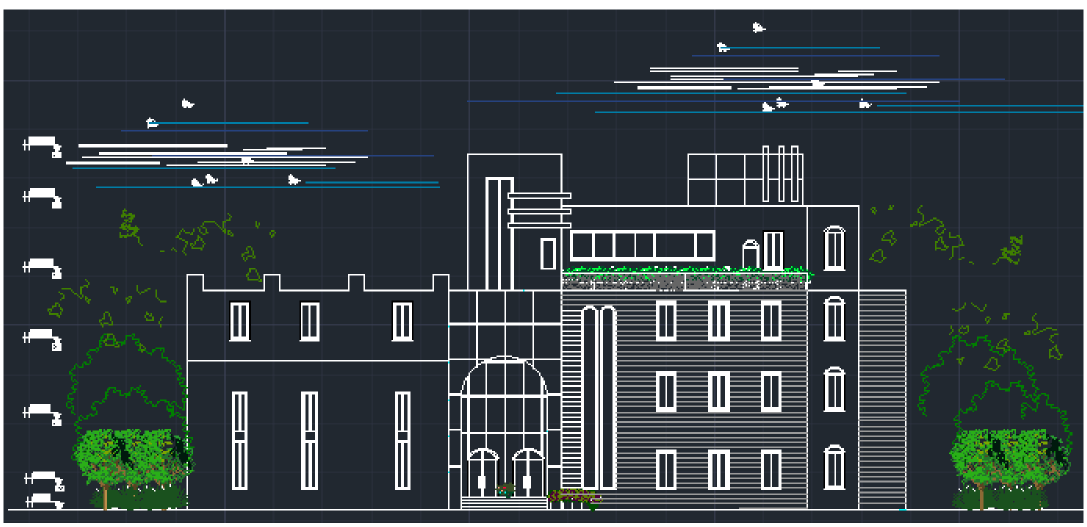


Figure (2-8):Eastern Elevation.

(2-7-3) Western Elevation:

It is the back facade of the building and shows the staircase that passes through all floors, and the distribution of openings appears in a beautiful civilized style. As shown in the following figure (2-9).

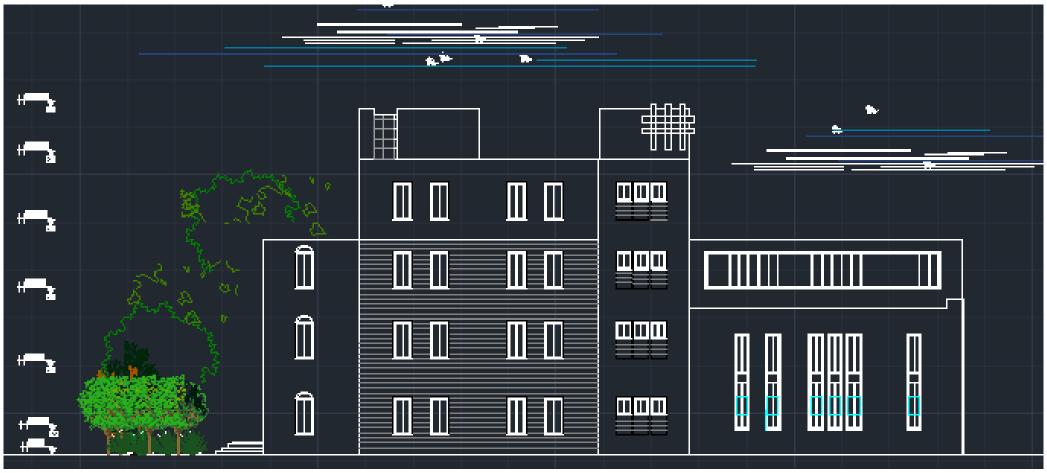


Figure (2-9):Western Elevation.

(2-7-4) Southern Elevation:

The blocks appear from this elevation in a coordinated, beautiful and civilized manner, and the four floors are clearly visible. As shown in the following figure (2-10).

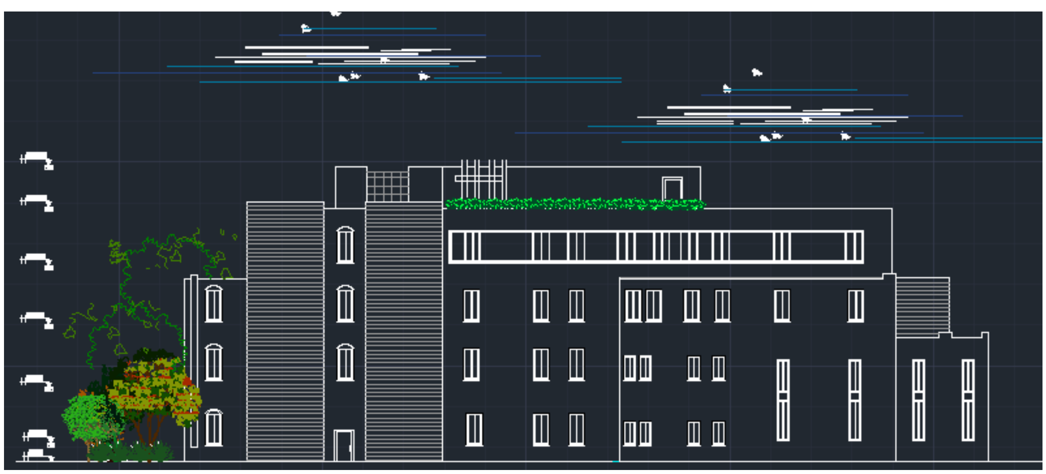
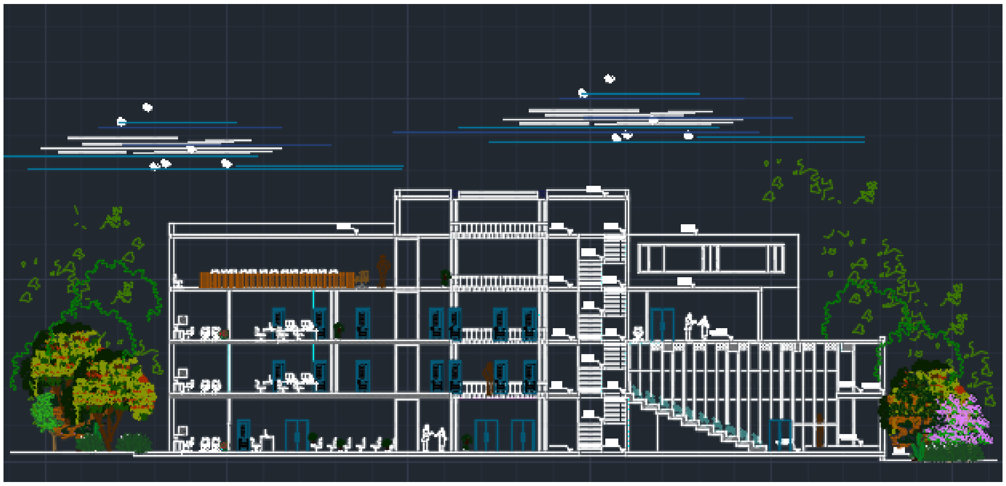


Figure (2-10):Southern Elevation.

(2-8) Longitudinal sections:

(2-8-1) Architectural section A-A:

In this section, the amphitheater for the theater appears, the basement floor is shown, and the staircase leading from the basement to the last floor is also shown.. As shown in the following figure (2-11).



Figure(2-11):section A-A.

(2-8-2) Architectural section B-B:

This section also shows the basement floor, and shows one of the means used to move between the floors of the building. As shown in the following figure (2-12).

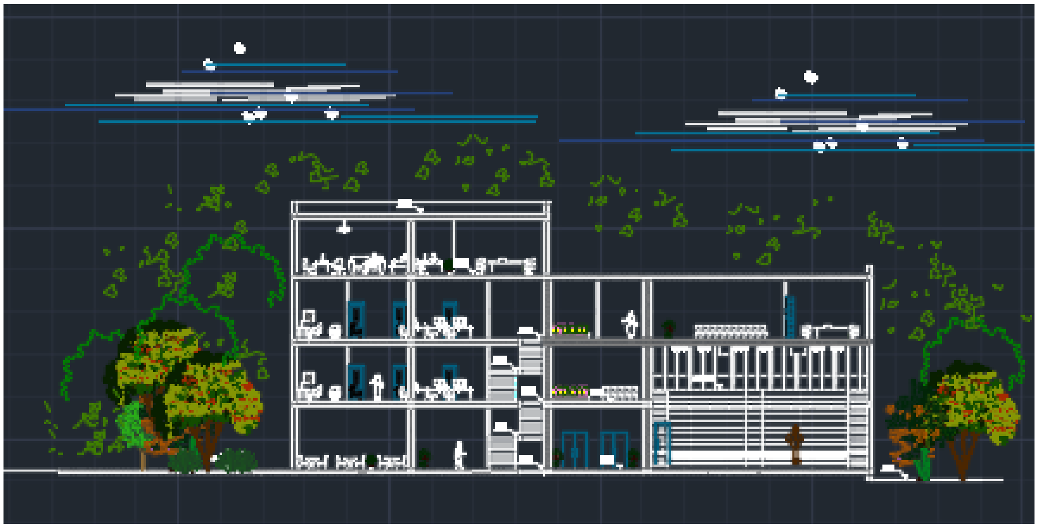


Figure (2-12):Section B-B.

(2-9) Description of Movement and Entrances:

There are many forms of movement around the building, where comfort, safety and ease of movement were taken into account, which is represented externally by access to the building and internally by horizontal and vertical movement, as for horizontal and vertical movement inside the building, it takes place in a linear manner through corridors between the spaces with clarity and ease of movement as well as about Through elevators and various stairs.

As for the entrances, there are a number of entrances to the building. On the northern elevation, there is the main entrance to the building, and there is another sub-entrance in the same elevation, there is another sub-entrance in the eastern elevation, and there is a ramp for people with special needs at the main entrance and the secondary entrance on the eastern elevation.

Chapter 3

"Structural Description"

(3-1) Introduction.

(3-2) The objective of the structural design.

(3-3) stages of structural design.

(3-4) loads.

(3-5) practical tests.

(3-6) the structural elements of the project.

(3-7) expansion joints.

(3-1) Introduction:

After studying the project from the architectural point of view, it is necessary to move to the structural side to study the structural elements and describe them accurately, where the nature of the loads placed on the building and how to deal with them are studied to come out with a structural design that meets all the requirements of safety and use and takes into account the economic aspect of the project.

The project also requires the structural design of the building and the selection of appropriate structural elements for the project to be constructed and taking into account the feasibility of its implementation on the ground so that the building is safe, and we preserve the architectural designs

(3-2) The objective of the structural design:

Structural design is an integrated, interdependent process that satisfies a range of Objectives and factors that will lead to a facility that achieves the desired objective, and these objectives are as follows:

- **Safety**: Where the building is safe in all circumstances and is resistant to changes and various natural disasters.
- **Economical cost** : It is to achieve the greatest degree of security for the origin at the lowest possible economic cost.
- **Ensure the efficiency of use (Serviceability)**: Avoid any defect in the origin, such as the presence of some cracks

And some types of landing that would annoy the users of the building.

- **Preserving the architectural design of the establishment.**

(3-3) Stages of structural design:

The structural design stages can be divided into two main stages:-

1- The first stage:-

It is the preliminary study of the project in terms of the nature and size of the project, in addition to understanding the project in all its various aspects and determining the building materials that will be approved for the project, then doing the basic structural analyzes of this system, and the expected preliminary dimensions of it.

And study the nature of the climate and the land on which the building is located.

2- The second stage: -

It is represented in the structural design of each part of the structure, in a detailed and accurate manner, according to the structural system that was chosen, and the work of the necessary structural details and designs for it in terms of drawing horizontal projections, vertical sectors, and details of the reinforcement steel.

(3-4) loads:

The loads to which the building is exposed are divided into different types, which are as follows:

(3-4-1) Dead Loads:-

They are the loads resulting from the self-weight of the main elements that make up the structure, on a permanent and fixed basis, such as tiles, cement mortar, and reinforced concrete, in terms of quantity and location, in addition to additional parts such as internal partitions of different types and any mechanical works or additions that are carried out permanently and permanently in the building, and can be calculated by determining the dimensions The structural element, and the densities of its constituent materials, and **Table (1-3**) shows the specific densities of the materials used in the project.

Item No	Material	Specific Weight (KN/m3)
1	Tile	23
2	Mortar	22
3	Sand	17
4	Hollow Block	10
5	Reinforced Concrete	25
6	Plaster	22
7	Backfill	21

Table (3-1): Specific density of the materials used.

In addition to the dead load resulting from the breakers (Partition load) = 1.5 kN/m^2

(3-4-2) live loads:

They are the loads that change in terms of amount and location on an ongoing basis, such as people, furniture, devices, equipment, and execution loads such as wood and equipment. The value of these loads depends on the nature of the use of the facility.

Its amount is usually taken from special tables in the different codes, and table (2-3) shows the live loads in the project, which are specified by reference to the Jordanian code.

Item No	The use	Live Load (kN/m^2)
1	Office rooms and bathrooms	2
2	Rest	2
3	Kitchens and stores	3
4	Auditoriums and theatres	5
5	Assembly halls with fixed seats	4
6	Public service halls	5
7	Stairs, corridors and rugs	4

Table (3-2):Live loads of building elements.

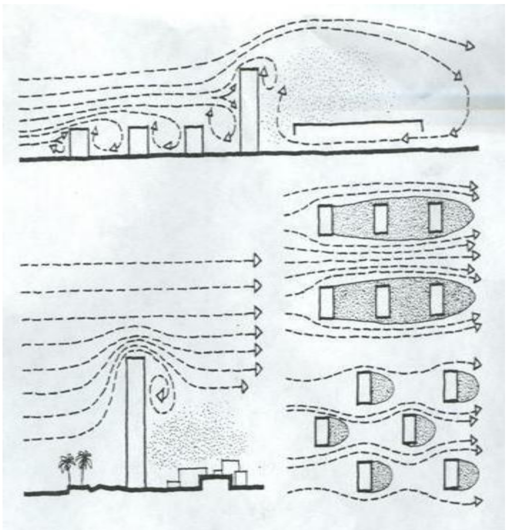
(3-4-3) Environmental loads: -

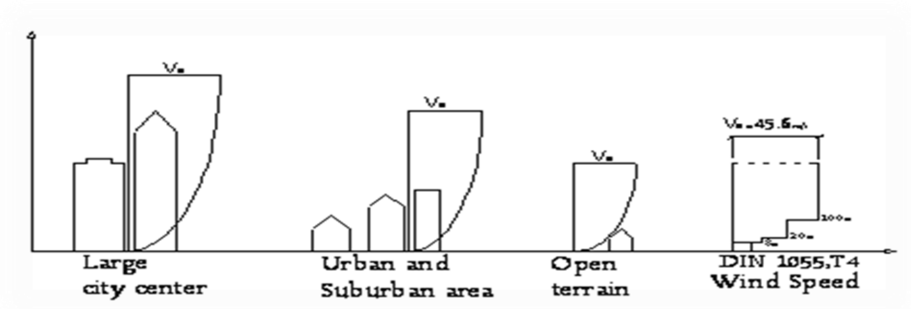
It includes the loads that result from the natural changes that pass through the structure, such as snow, winds, and heavy loads

Earthquakes and loads resulting from soil pressure, which vary in magnitude and direction and from one region to another, and can be considered as part of the live loads.

(3-4-4) Wind Loads:

Wind loads affect horizontal (lateral) forces on the building, and to determine the wind loads, the maximum wind speed was relied upon, which changes with the change in the height of the structure above the ground and its location in terms of being surrounded by tall buildings or the presence of the structure itself in a high or low location, and many other variables .High buildings must be designed to resist the force of horizontal winds.





Figure(3-1):The effect of wind on buildings in terms of building height and the surrounding environment.

(3-4-5) Snow Loads:

Snow loads depend on the height of the area above sea level and the shape of the roof, and they are determined using different building codes, through tables that take the height of the structure above sea level and the angle of inclination of the roof as a basis for determining the value of the forces that affect the structure, and the following table shows the values of snow loads according to The height above sea level is taken from the Jordanian building code.

Snow Loads (kN/m^2)	The height above the ground(h)(m)
0	$h < 250$
(h-250)/1000	$500 > h > 250$
(h-400) / 400	$1500 > h > 500$
(h – 812.5)/ 250	$2500 > h > 1500$

Table (3-3): Snow loads according to height above sea level.

Based on the previous snow load schedule and after determining the height of the building above sea level, which is equal to (850m).For the third item snow loads have been calculated .And according to the following:

$$SL = (850 - 400) / 400 = 1.125\ kN/m^2$$

(3-4-6) Earthquake loads:

Earthquakes result from horizontal and vertical vibrations, due to the relative movement of the rock layers of the earth, which results in shear forces that affect the facility. These loads must be taken into account when designing in order to ensure the building's resistance to earthquakes in the event that they occur, and thus reduce potential damages as a result of an earthquake.

In this project, it will be resisted by the shear walls distributed in the building based on the structural calculations for it, which will be used for it, to avoid the effects resulting from earthquakes such as:

- The limits of the validity of the building for operation (Serviceability) in terms of avoiding any excessive subsidence (Deflection) and avoiding (Cracks) that negatively affect the required architectural appearance.
- The shape and aesthetic aspects of the establishment.

(3-5) practical tests:

The construction study of any building precedes the geotechnical studies of the site, and it means all the work related to the exploration of the site and the study of soil, rocks and groundwater, and the analysis of information and its translation to predict the way the soil behaves when building on it, and what the structural engineer is most interested in is obtaining the necessary soil bearing strength To design the foundations of the building, and from this step, the type of foundation that will be used for the building can be approved.

(3-6) Structural Elements:

Buildings usually consist of a group of structural elements that intersect with each other to withstand the loads on the building, and they include:Slabs, Beams, columns, stairs, and foundations. Figure (2-3) shows an illustration of some structural elements of the building.

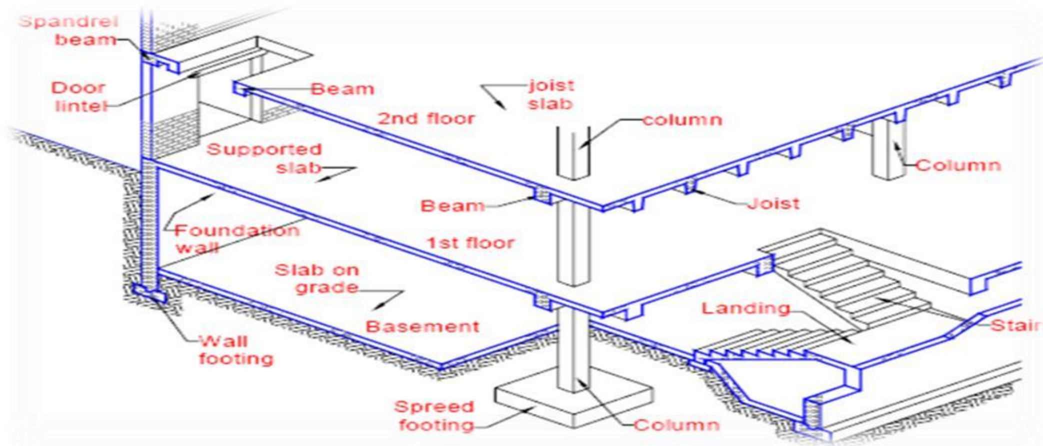


Figure (3-2): Illustration of some structural elements of the building.

The project contains the following elements:-

(3-6-1) Slabs: -

They are the structural elements that are capable of transferring vertical forces due to the loads affecting them to the load-bearing structural elements in the building such as bridges, columns, walls, steps and foundations, without subjecting them to deformations.

Given the presence of many different activities in the building and taking into account the architectural requirements, the following types of Slabs will be used in the project.

(3-6-1-1) Solid slabs:

are divided into:

- One way solid slab .
- Two way solid slab.

One way solid slab were used in this project.

(3-6-1-2) Ribbed Slabs:

which are divided into:

- One way ribbed slab
- Two way ribbed slabs.

Where both were used in the design of the building in the project.

The one-way ribbed slab are used to cover the spaces in which the dimensions between the columns range from six to seven meters. As for the two-way ribbed slab, they are used in the case of relatively large areas. In the structural design of this project, the one-way ribbed slab and all Types of ribbed slab.

One way ribbed slabs:

It is one of the most famous methods used in designing slabs in these countries, and it consists of a row of bricks followed by nerves, and the reinforcement is in one direction as shown in Figure (3-3). It is characterized by its light weight and effectiveness, and it is the most widely used in Palestine and in our project as well.

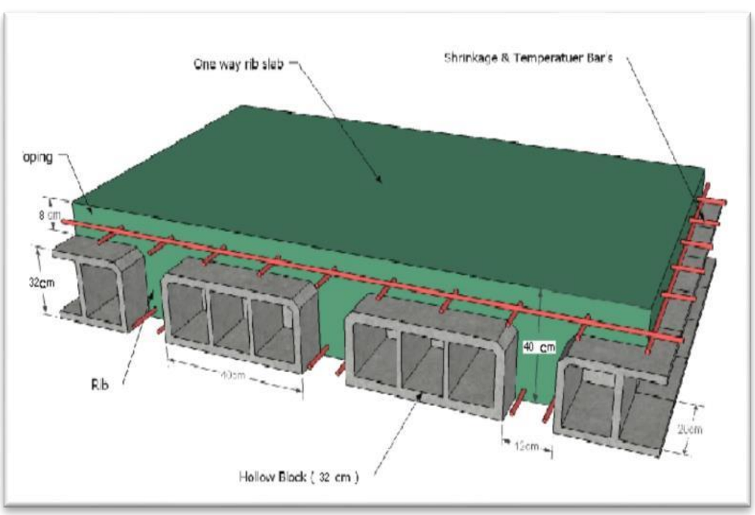


Figure (3-3):One-way ribbed slabs.

➢ <u>Two-way ribbed slabs:</u>

It is similar to the previous one in terms of components, but differs in terms of the reinforcement being in two directions, and the load is distributed in all directions, and two bricks and a beam are taken into account when calculating their weight in both directions, as shown in Figure (4-3) and we also used this type in our project

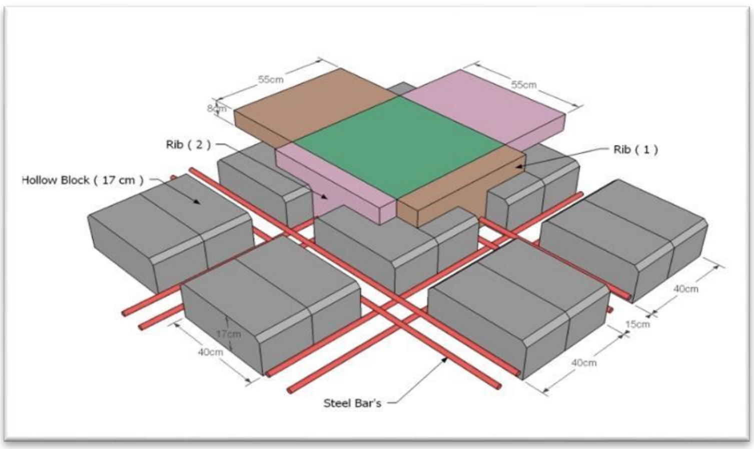


Figure (3-4): Two-way ribbed slabs.

➢ <u>One way solid slabs:</u>

They are used in areas that are frequently subjected to dynamic loads, in order to avoid vibration due to the low thickness. They are usually used in stairs slabs, as in Figure (5-3)

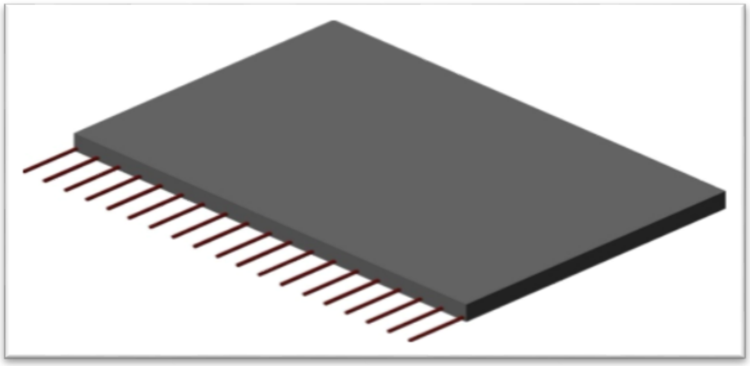


Figure (3-5):One-way solid slabs.

- **Two way solid slabs:**

It is used in the event that the effective loads are greater than the amount that the one-way solid slabs, and at that time the design of this type of slabs is resorted to, because this can resist the loads more, as the main reinforcement is distributed in two directions (as shown in Figure (3-6).

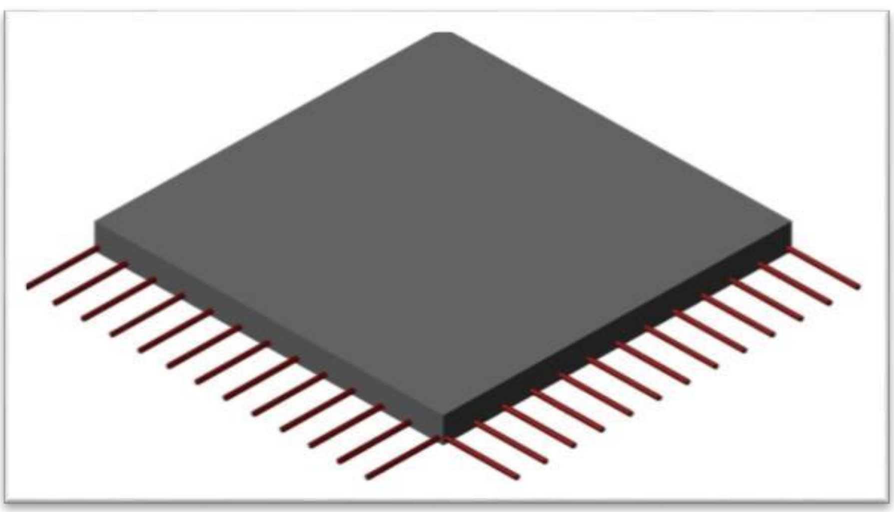


Figure (3-6): Two-way solid slabs.

(3-6-2) Beams:-

They are basic structural elements in the building that transfer the loads on the ribs to the columns, as they are divided into:

1- Hidden beams, whose height is equal to the height of the slab.

2- Dropped beams, which are higher than the height of the slab, and the extra part of the beam is highlighted in one of the lower or upper directions, and it is called L-section or T= section

The reinforcement shall be with horizontal steel bars to resist the moment on the beam, and with stirrups to resist shear forces. Figure (7-3) shows the types of beams that were used in the project.

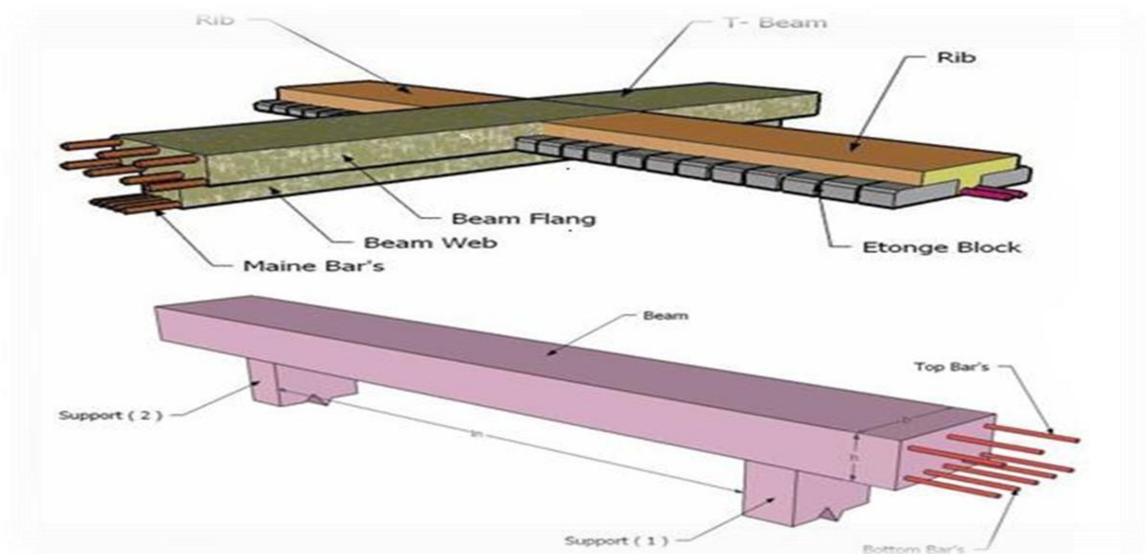


Figure (3-7): Types of beams that were used in the project.

(3-6-3) Columns:

They are basic and major structural elements in the structure, where the loads are transferred from the slab to the beams, and the beams transfer them in turn to the columns, then to the foundations of the building, so they are an essential intermediate element, and they must be carefully designed to be able to transfer and distribute the loads located on them and the columns are of two types in terms of dealing with them In structural design:-

1- Short columns.

2- Long columns.

As for the architectural form or the engineering section, the project contains three types of columns, which are square, rectangular and circular.

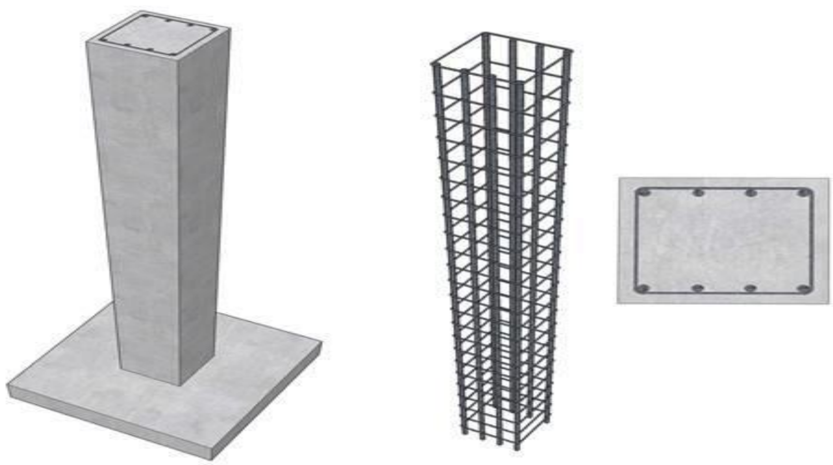


Figure (3-8): Some Types of columns that were used in the project.

(3-6-4) shear walls:

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

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

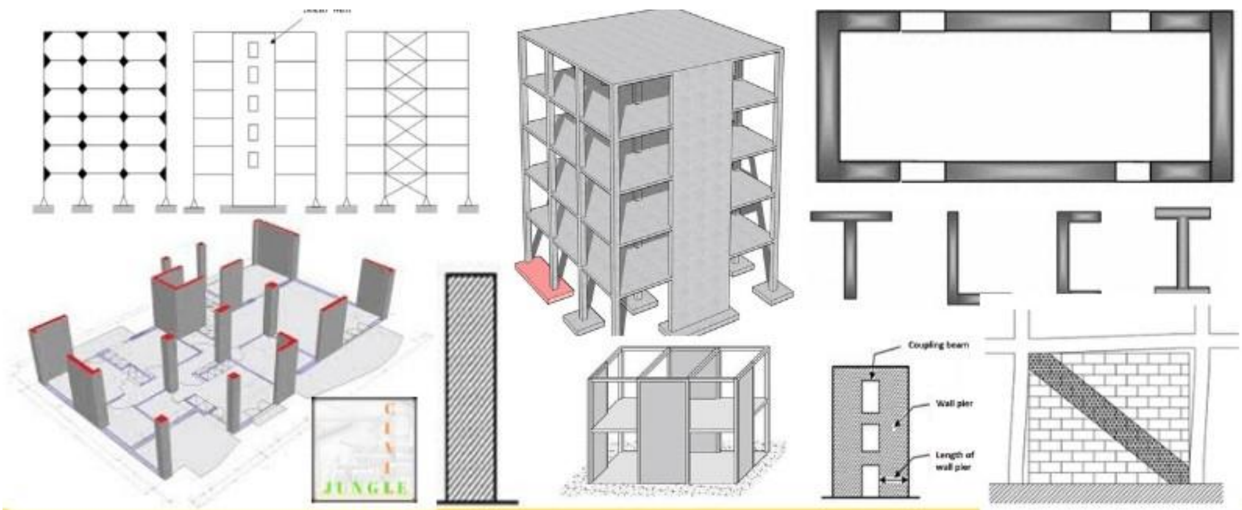


Figure (3-9): Shear Walls.

(3-6-5) Foundations:

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

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

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

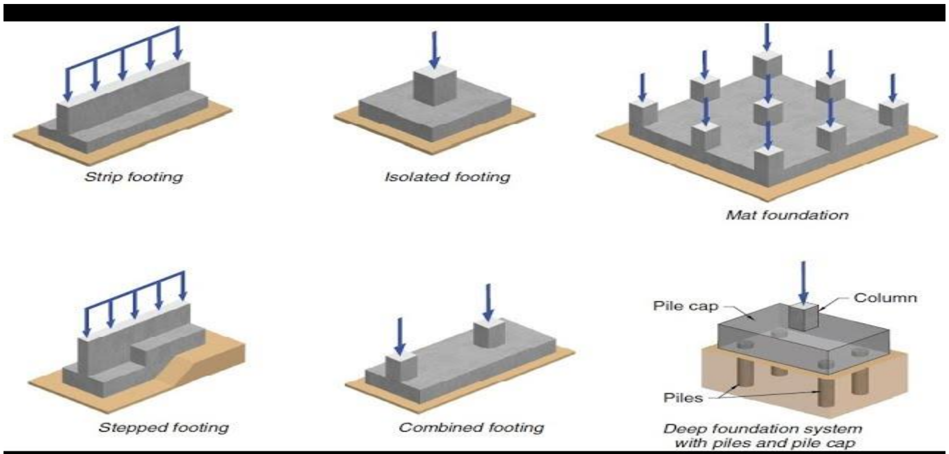


Figure (3-10): Foundation types.

(3-6-6) Stair:

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

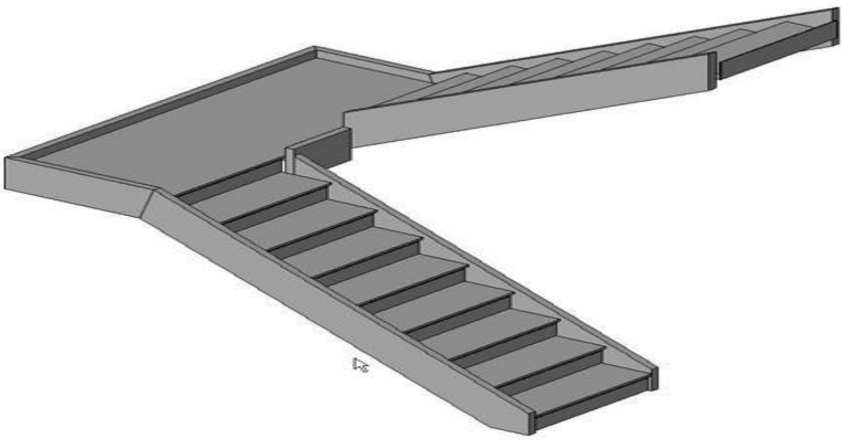


Figure (3-11) Stair.

(3-7) expansion joints:

In building blocks with large horizontal dimensions or with special shapes and conditions, thermal expansion joints or subsidence joints are implemented. The joints may be for both purposes. When analyzing the facilities to study them as resistant to earthquake actions, these joints are called seismic joints. These joints have some requirements and recommendations for them, and they should also be used Thermal expansion joints in the building block according to the approved code, provided that these joints reach the upper face of the foundations without penetrating them, and the maximum distances for the dimensions of the building block are as follows:

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

The width of the separator shall not be less than 3 metres

In this project, a vertical expansion joint was used.

Chapter 4

"Structural Analysis & Design"

(4-1) Introduction.

(4-2) Design method and requirements.

(4-3) Factored loads.

(4-4) Determination of minimum thickness of structural members.

(4-5) Design of one way ribbed slab (F1-R21).

(4-6) Design of Beams (F1-B37(100*35).

(4-7) Design of column(G2).

(4-8) Design of isolated footing (F1(1.45*1.45)).

(4-9)Design of stair.

(4-9) Design of shear wall.

(4-1)Introduction:

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

Concrete used in most construction work is reinforced with steel. When concrete structure members must resist extreme tensile stresses, steel supplies the necessary strength. Steel is embedded in the concrete in the form of a mesh, or roughened or twisted bars. A bond forms between the steel and the concrete, and stresses can be transferred between both components.

In this project, all of design calculation for all structural members would be made upon the structural system which was chosen in the previous chapter.

So, in this project, there are many type of slabs such that “one way ribbed slab”, They would be analyzed and designed by using finite element method of design, with aid of a computer program called "Beam-D- Software” to find the internal forces, deflections and moments for ribbed slabs, and then handle calculation would be made to find the required steel for all members.

(4-2) Design method and requirements:

The design strength provided by a member, its connections to other members, and its cross sections in terms of flexure, and load, shear, and torsion is taken as the nominal strength calculated in accordance with the requirements and assumptions of ACI-318-14 code.

The design strength provided by a member is calculated in accordance with the requirements and assumptions of ACI code (318_14).

➢ 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.

➢ Material:

Reinforced Concrete: B300 , $fc' = 24\ N/mm^2$ (Mpa)

Reinforcement Rebars: $fy = 420\ N/mm^2$(Mpa)

➢ Strength reduction factors (Ø):

According to ACI a reduction factor for structural elements must be included in the calculation of concrete sections, these factors are less than 1.0 for safety purposes, 0.9 for tension controlled sections, 0.75 (Spiral) or 0.65 (Stirrups) for compression controlled sections, 0.75 in shear calculation and 0.6 for plain concrete sections. The strength factor (Ø) changes with net tensile strain of the cross section as illustrated in the following figure:

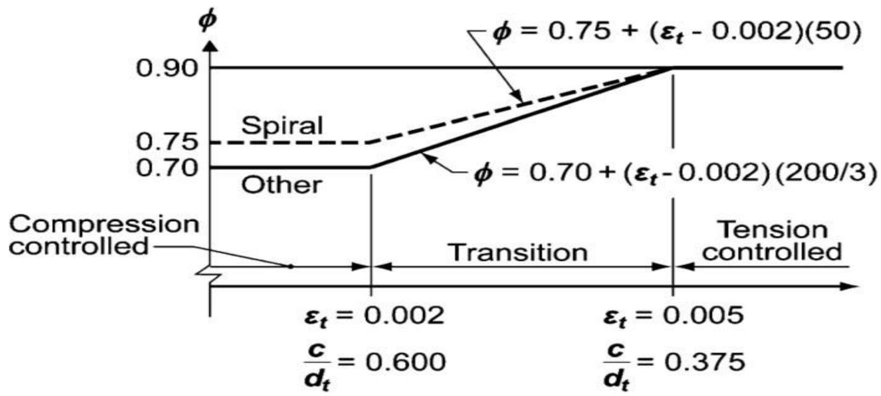


Fig. (4-1):Variation of Ø factor with net tensile strain (ACI 318)

(4-3) Factored loads:

The factored loads used in the structural analysis and design according to ACI-318-11(9.2) eq.
, is determined as follows:

$$\mathbf{Wu = 1.2DL + 1.6LL}$$

Where;
Wu: Ultimate Load (kN)
DL: Dead Load (kN)
LL: Live Load (kN)

(4-4) Determination of minimum thickness of structural members:

Minimum thickness of non-prestressed beams or one-way ribbed slabs unless deflections are calculated. (ACI 318M-11)

Member	Minimum Thickness, h			
	Simply Supported	One-end continuous	Two-ends continuous	Cantilever
Ribs & Beams	Span(L)/16	Span(L)/18.5	Span(L)/21	Span(L)/8

Table (4-1): Determination of minimum thickness of structural member.

For rib F1-R21 Ground floor:

$$\frac{L}{21} = \frac{7.25}{21} = 34.5\ cm$$ …For both end continuous. (for rib)

Select Slab thickness **h=35** cm but we run it on safe and Atir and the deflection was ok.

(4-5) Design of one way ribbed slab (F1-R21):

One way ribbed slab Design procedure is explained in the following steps:

(4-5-1) Design of Topping:

Topping in One way ribbed slab can be considered as a strip of 1-meter width and span of hollow block length with both ends fixed in the ribs.

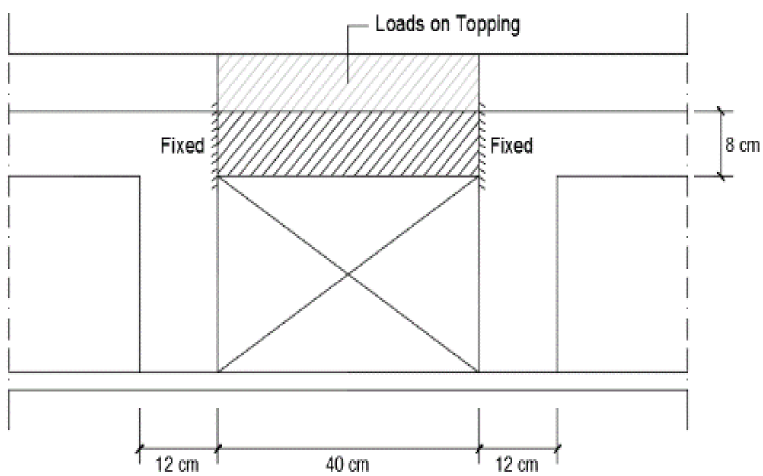


Figure (4- 2):System of Topping.

(4-5-1-1) Calculation of Loads on Topping:

Dead loads that act on Topping can be calculated as shown in the following table :

→ Dead Load For 1m strip:

No.	Material	Quality Density KN/m^3	DL (KN/m)
1	Topping	25	0.08×25 ×1= 2
2	Coarse Sand	17	0.07×17×1 = 1.19
3	Mortar	22	0.03×22×1 =0.66
4	Tile	23	0.03×23×1 =0.69
5	interior partion	2.3*1=2.3 KN/m^2	
		∑ =	6.84 KN/m

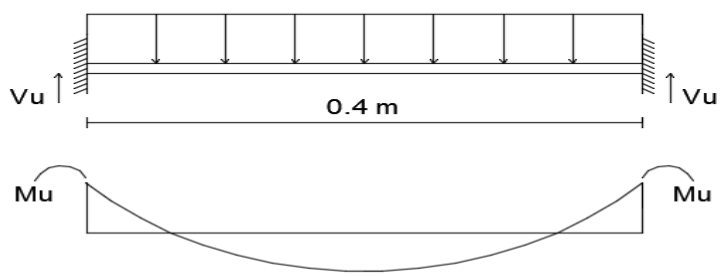
Table(4- 2): Dead Load Calculation For Topping.

Live Load For 1m strip = 4 × 1 = 4 kN/m

Factored load (W_u) = 1.2×DL+1.6×LL

= 1.2×6.84 + 1.6×4 = 14.6 kN/m. (Total Factored Load) .

$$M_u = \frac{W_u * l^2}{12} = \frac{14.6 * 0.4^2}{12} = 0.195\ kN.m\ .$$



Figure(4-3)Moment Shape For Topping.

(4-5-1-2) Design Strength of Topping:

- **Moment Design Strength :**

For Plain concrete section with “b = 1 m & h = 8 cm”

$$\emptyset M_n = 0.55 * 0.42 * \sqrt{fc`} * b * \frac{h^2}{6}$$

$$\emptyset M_n = 0.55 * 0.42 * \sqrt{24} * 1000 * 80^2/6 = 1.2\ KN.m$$

$$\emptyset M_n(plane\ concrete\ ) = 1.2KN.m > M_u\ max = 0.195\ KN.m$$

No structural reinforcement is needed .

Therefore , shrinkage and temperature

reinforcement must be provided.

For the shrinkage and temperature reinforcement :-

$$\rho_{min} = 0.0018$$

$$A_s = \rho * b * h = 0.0018 * 1000 * 80 = 144\ mm^2.$$

Number 0f Ø8= $\frac{As_{req}}{A_{bar}} = \frac{144}{50.3}$ = 2.87→ Take it 3

→ Spacing(S)=300mm

Use 3Ø8/300mm whith As 150.8mm^2/m strip

- Step (s) is the smallest of :-

1)S ≤ 380 $(\frac{280}{fs})$ – 2.5 × C_c ≤ 300 $(\frac{280}{fs})$

= 380 × ($\frac{280}{\frac{2}{3}fy}$) – 2.5× 20 ≤ 300 × ($\frac{280}{\frac{2}{3}fy}$)

$$= 380 \times \left(\frac{280}{\frac{2}{3} * 420} \right) - 2.5 \times 20 = 330 \text{ mm}$$

$$S \leq 300 \times \left(\frac{280}{\frac{2}{3} * 420} \right) = 300 \text{ mm.}$$

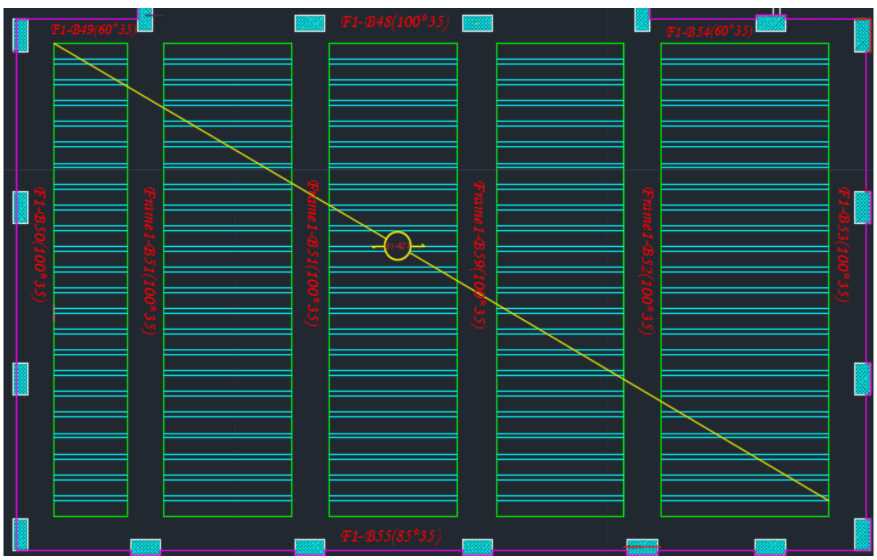
2) $S \leq 3 \times h = 3 \times 80 = 240$ mm ➡ controlled.

3) $S \leq 450$ mm.

Take S= 200 mm $< S_{max} = 240$ mm - ok .

- **Select mesh Ø8/20 cm in both directions.**

<u>(4-5-2) Design of one way- ribbed slab (F1-R21):</u>



Figure(4-4): Spans of rib (F1-R21)location

(4-5-2-1) Loads Calculation for Rib (F1-R21):

Rib (F1-R21) is selected to be designed , the following figure shows its location in First floor

No	Material	Quality Density KN/m^3	DL (KN/m)
1	Topping	25	0.08×25 ×0.52= 1.04
2	Coarse Sand	17	0.07×17×0.52 = 0.6188
3	RC Rib	25	0.24×25×0.12 = 0.66
4	Mortar	22	0.03×22×0.52 =0.3432
5	Hollow block	10	0.24×10×0.4 = 0.88
6	Tile	23	0.03×23×0.52 =0.3588
7	Plaster	22	0.03×22×0.52 = 0.3432
8	interior partion		2.3*0.52=1.196
		∑ =	5.58 KN/m

Table(4- 3): Dead Load Calculation For Rib (F1-R21).

- DL=**5.58** **KN/m**
- **LL = 4*0.52=2.08** KN/m

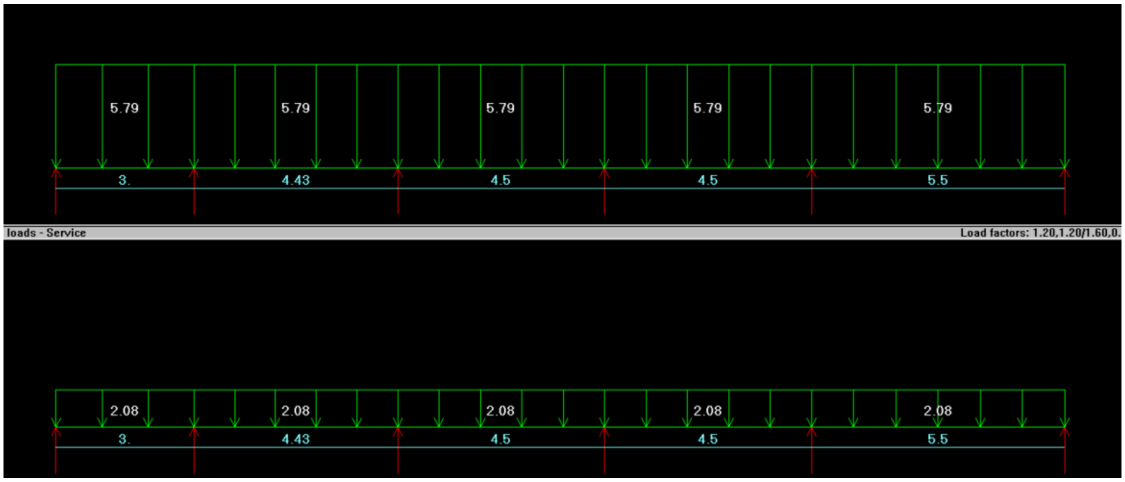


Figure (4- 5): service load For rib (F1-R21) – (kN)

Rib geometry:

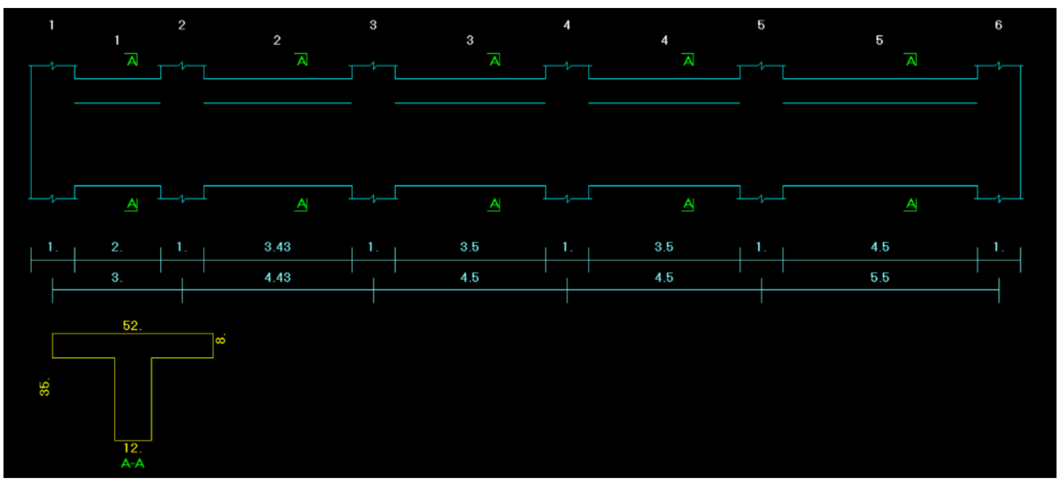


Figure (4- 6):geometry of Rib (F1-R21)

Requirements for Ribbed Slab (T-Beam Consideration According to ACI) are as follows :

- $bw \geq 10cm \rightarrow$ select $bw = 12$ cm.
- $h \leq 3.5\ bw = 3.5 \times 14 = 49$ cm $\rightarrow$ select $h = 35$ cm.
- $Tf \geq \frac{Ln}{12} \geq 50$ mm $\rightarrow$ select $tf = 8$ cm.

(4-5-2-2)Analysis:

Figure (4-5)& (4-6) shows the shear and Moment envelope of the rib (F1-R21) obtained from Atir:

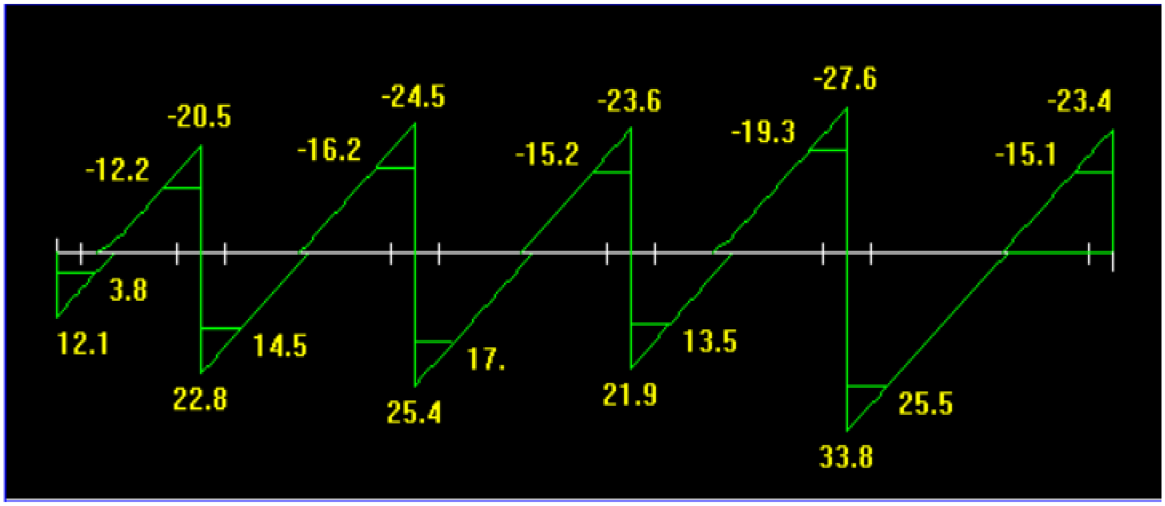


Figure (4- 7):Shear envelope for rib (F1-R21) – (KN)

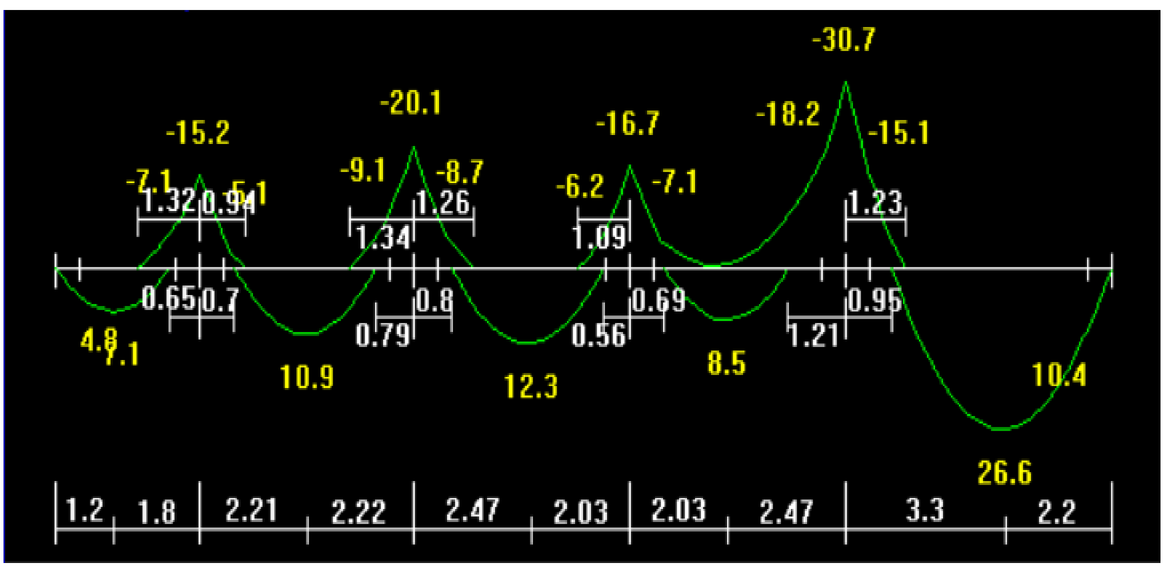


Figure (4- 8):Moment envelope for rib (F1-R21) – (kN.M)

(4-5-2-3) Design of flexure:-

(4-5-2-3-1) Design of Positive moment of rib (F1-R21):

Maximum negative moment Mu (+) = +26.6 KN.m.

Mnf = 0.85 * 24 * 80 *520 (314 - (80/2)) * 10^-6=232.53 KN.m

Ø Mnf = 0.9 * 232.53= 230.2 KN.m

→ Ø Mnf =230.2 KN.m >> Mu= 26.6 KN.m

Design as rectangular section with b = be = 520 mm

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

350 - 20 - 10 - (12/2) =314 mm

$Mn = Mu / Ø = 26.6/ 0.9=29.56$ KN.m

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

$$R_n = \frac{M_n}{b*d^2} = \frac{29.56*10^6}{0.9*520*314^2} = 0.64 \text{ MPa}$$

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

$$= \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*0.64*20.6}{420}}\right) = 0.001549$$

→$As_{req} = \rho \times b \times d = 0.001549 \times 520 \times 314 = 253 \text{ mm}^2$

$$As_{min} = \frac{0.25\sqrt{f'_c}}{(f_y)} * b_w * d \geq \frac{1.4}{f_y} * b_w * d$$

$$= \frac{0.25*\sqrt{24}}{420} * 120 * 314 \geq \frac{1.4}{420} * 140 * 314$$

$=109.87 \text{ mm}^2 < 125.6 \text{mm}^2$ ………….

125.6 mm^2 controlled.

→$As_{min} = 125.6 \text{ mm}^2 < As_{req} = 253 \text{mm}^2$.

Number 0f Ø= $\frac{As_{req}}{A_{bar}} = \frac{253}{154}$ = 1.64→ take it 2

USE 2 Ø14 with As_{prov} = 307.88 mm^2>As_{req} = 253mm^2... OK.

∴ Use 2 Ø14

(4-5-2-3-2) Design of negative moment of rib (F1-R21):

Maximum negative moment Mu (-) = -18.2 KN.m.

Assume bar diameter Ø 12 for main negative reinforcement.

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

350 - 20 - 10 - (12/2) =314 mm

Mn = Mu / Ø = 18.2/ 0.9=20.22 KN.m

$$m = \frac{f_y}{0.85\, f_c'} = \frac{420}{0.85*24} = 20.6$$

$$R_n = \frac{M_n}{b*d^2} = \frac{20.22*10^6}{0.9*120*314^2} = 1.9 \text{ MPa}$$

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

$$= \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*1.9*20.6}{420}}\right) = 0.004757$$

→As_{req} = ρ × b ×d =0.004757 × 120 × 314 = 179.24 mm^2. > As_{min} =125.6mm^2

USE 2 Ø12 with As_{prov} = 226.2 mm^2>As_{req} = 179.24 mm^2... OK.

∴ Use 2 Ø12

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

d=350 - 20 - 10 - (14/2)=313mm

a= (A_s × fy / 0.85 × f_c' × b)

a=(226.2*420/.85*24*120)=38.8mm

$$c = \frac{a}{\beta_1} = \frac{38.8}{0.85} = 45.65 \text{ mm}$$

d= 314

$$\varepsilon_s = \frac{313-45.65}{45.65} * 0.003$$

= 0.018> 0.005 (tension control section).

∴ ∅ =0.9 .... OK.

(4-5-2-4) Design of Shear for rib (F1-R21):

Vu max = 25.5 KN

Ø .Vc = 1.1*(1/6) $\sqrt{24}$ *120 *315*10^-3 =25.46 KN

Vu=25.5 KN ≤ Ø .Vc = 25.46 KN

- Case 2
- Minimum shear Reinforcment is Required.

Try Ø 8 With 2 Legs whith As =100.53 mm^2

(Av min/S) ≥(1/3)*(120/420)* 10^-3 =9.52*10^-5……….Controlled

≥(1/16)(($\sqrt{24}$ ∗ 120)/420))= 8.75*10^-5.

S=100.53*10^-6/(9.52*10^-5)=1.056 m=1056 mm

S max ≤ (315/2)=157.5mm ……Controlled

S max ≤ 600mm

S=1056mm> 157.5mm Not Ok

Take S = 125 mm.

- Use Ø 8 With 2 Legs /125mm

(4-6) Design of Beam (F1-B37(100*35)):

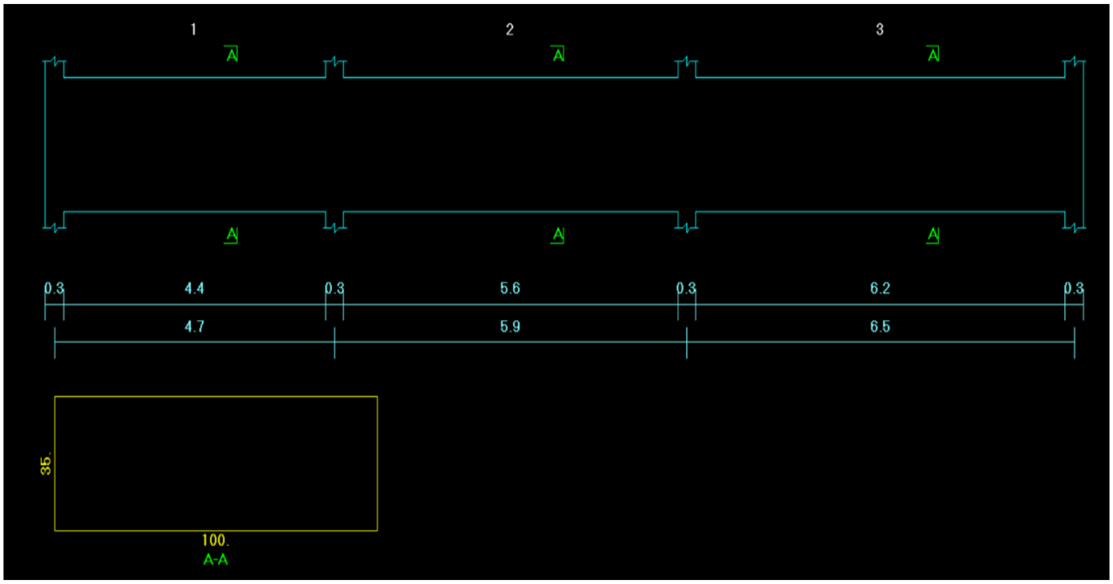


Figure (4- 9):Geometry Of Beam (F1-B37(100*35))

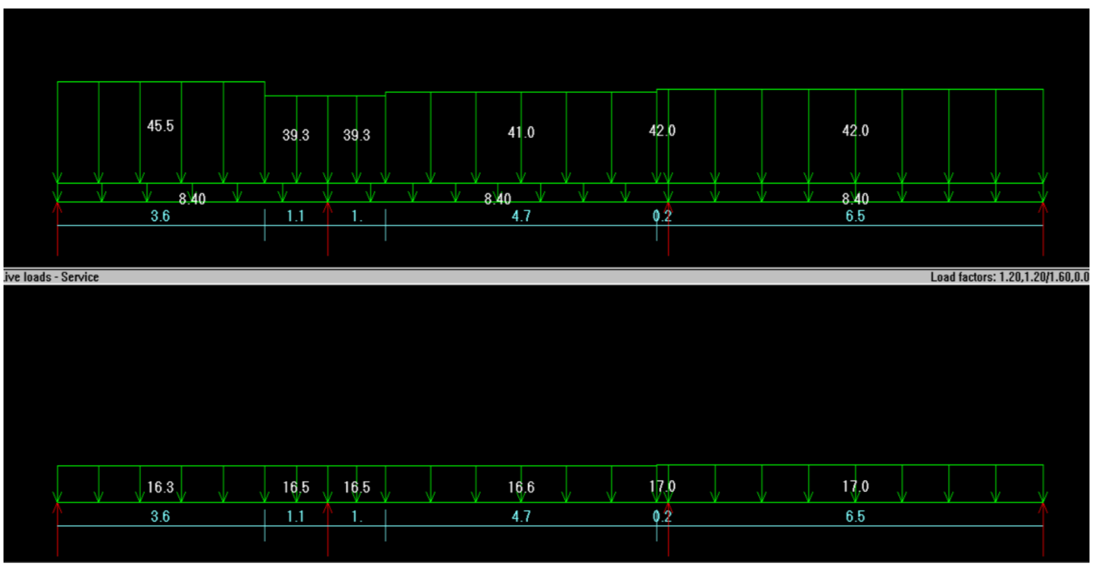


Figure (4- 10): Load On Beam (F1-B37(100*35))

(4-6-1)Design of flexure:-

(4-6-1-1)Design of Maximum Positive Moment:

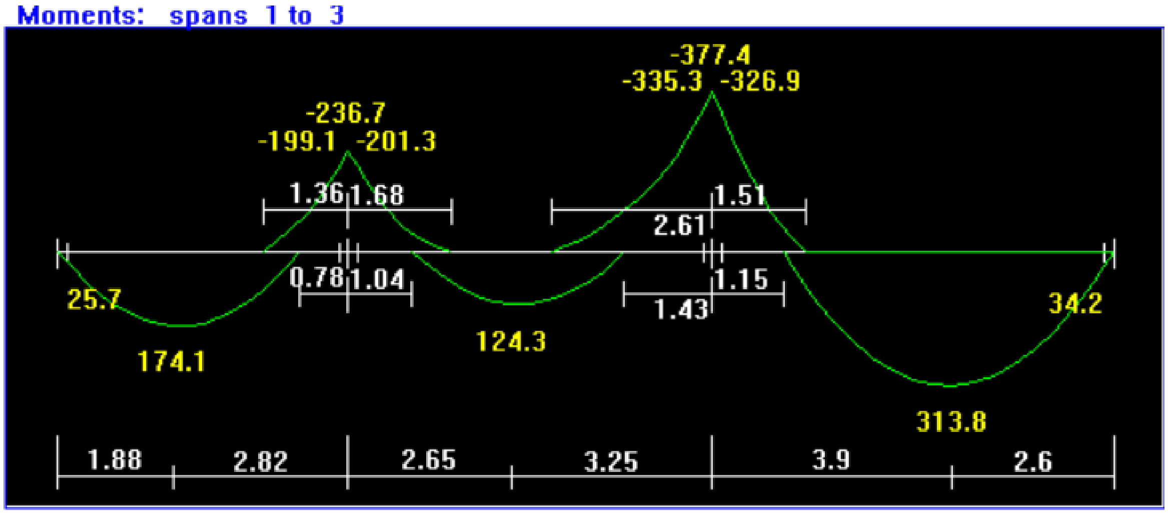


Figure (4- 11): Moment Envelope for beam (F3-B3 (100*35)).

→**Mu max = 313.8 KN.m**

Assume bar diameter Ø20 for main positive reinforcement

d = 350-40-10-10= 290mm

Mn = 0.85 * 24 * 350 *1000 (290 - (350/2)) * 10^-6=821.1 KN.m

Mu/ Ø=(313.8/0.9)=348.67 KN.m < Mn= 821.1 KN.m

Design as rectangular section with b = 1000 mm

$$R_n = \frac{M_n}{b*d^2} = \frac{348.67*10^6}{0.9*1000*690^2} = 4.61 \text{ MPa}$$

$$m = \frac{f_y}{0.85\ f_c'} = \frac{420}{0.85*24} = 20.59\text{mm}$$

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

$$= \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2*4.61*20.59}{420}}\right) = 0.0126$$

$As_{req} = \rho \times b \times d = 0.0126 \times 1000 \times 290 = 3654\ mm^2$

$$As_{min} = \frac{0.25\sqrt{f_c'}}{(f_y)} * b_w * d \geq \frac{1.4}{f_y} * b_w * d$$

$$= \frac{0.25*\sqrt{24}}{420} * 400 * 690 \geq \frac{1.4}{420} * 400 * 690$$

$=804.83\ mm^2 < 920mm^2$ ………….

$920\ mm^2$ controlled.

$\rightarrow As_{min} = 920\ mm^2 < As_{req=}\ 3654\ mm^2$.

Use ∅ 25

Number 0f $\emptyset = \frac{As_{req}}{A_{bar}} = \frac{3654}{490.87} = 7.44 \rightarrow$ take it 8

S= (400-80-20-8*25)/4 =25mm =25 mm…..ok

Use 8∅ 25 whith As = $3926.96mm^2$ > Asreq= $3654\ mm^2$

- Check strain :

d = 350 - 40 – 10 - (25/2)= 287.5 mm

a= (A_s × fy / 0.85 × f_c' × b)

a=(3926.96*420/.85*24*1000)=80.85mm

$$c = \frac{a}{\beta_1} = \frac{80.85}{0.85} = 95.12\ mm$$

$$\varepsilon_s = \frac{287.5-95.12}{95.12} * 0.003$$

= 0.0061> 0.005…. ok(tension control section).

∴ ∅ =0.9 .... OK

(4-6-1-2) Design of Maximum Negative Moment:

→Mu max = 335.3 KN.m

$$R_n = \frac{M_n}{b*d^2} = \frac{335.3*10^6}{0.9*1000*287.5^2} = 4.51 \text{ MPa}$$

m= 20.59 mm

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

$$= \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2*4.51*20.59}{420}}\right) = 0.01229$$

$As_{req} = \rho \times b \times d = 0.01229 \times 1000 \times 287.5 = 3533.38 \text{ mm}^2$

$$As_{min} = \frac{0.25\sqrt{f_c'}}{(f_y)} * b_w * d \geq \frac{1.4}{f_y} * b_w * d$$

$$= \frac{0.25*\sqrt{24}}{420} * 1000 * 287.5 \geq \frac{1.4}{420} * 1000 * 287.5$$

$= 838.4 \text{ mm}^2 < 958.34 \text{mm}^2$ …………

958.34 mm^2 controlled.

$\rightarrow As_{min} = 958.34 \text{ mm}^2 < As_{req=}\ 3533.38 \text{ mm}^2$.

$$\text{Number 0f } \emptyset = \frac{As_{req}}{A_{bar}} = \frac{3533.38}{490.87} = 7.2 \rightarrow \text{ take it } 8$$

Use 8 Ø 25 whith As = 3926.96 mm^2> Asreq= 3533.38 mm^2

- Check strain :

$a = (A_s \times fy\ / 0.85 \times f_c' \times b)$

a=(3926.96 *420/.85*24*1000)=80.85

$$c = \frac{a}{\beta_1} = \frac{80.85}{0.85} = 95.12 \text{ mm}$$

$$\varepsilon_s = \frac{287.5-95.12}{95.12} * 0.003$$

= 0.0061> 0.005…. ok(tension control section).

∴ Ø =0.9 .... OK

(4-6-2) Design of Shear For Beam (F1-B37(100*35)):

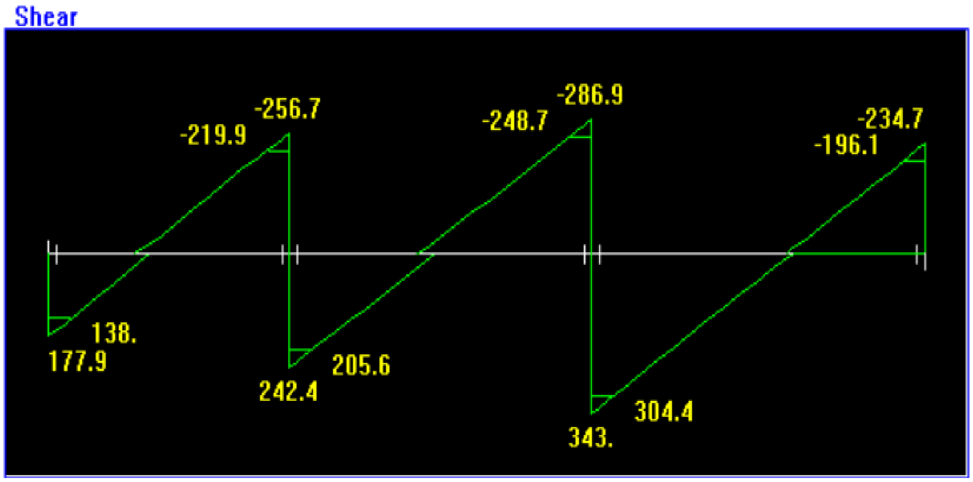


Figure (4- 12):Shear Envelope for beam (F1-B37(100*35))

Max Vu = 304.4 KN .

Vs = (Vu / Ø) -Vc = (304.4/0.75) – 234.74 = 171.13 KN.

Ø Vc = (1/6) * 0.75 *$\sqrt{24}$ *1000 * 287.5 * 10^-3 = 176.1 KN.

CASE 1 ➡ Vu ≤ ØVc/2

304.4 KN < 88.1 KN………..NOT OK

CASE 2 ➡ ØVc/2 < Vu ≤ ØVc

88.1 KN < 304.4 KN < 176.1 KN ………..NOT OK

Vs min = (1/16) * $\sqrt{24}$ * 1000 *287.5* 10^-3 = 88.1 KN

OR Vs min = (1/3) * 1000 *287.5* 10^-3 = 95.84 KN………..Controlled.

Ø(Vc + Vs min) = 0.75 (234.74 + 95.84) = 247.94 KN

CASE 3 ➡ ØVc < Vu ≤ Ø(Vc + Vs min)

$176.1 < 304.4 \leq 247.94$………..NOT OK

$Vs' = (1/3) * \sqrt{24} * 1000 * 287.5 * 10^{-3} = 469.49$ KN.

$\emptyset(Vc + Vs') = 0.75\ (234.74 + 469.49) = 528.2$ KN

$\emptyset(Vc + Vs\ min) \leq Vu \leq \emptyset(Vc + Vs')$

$247.94 < 304.4 < 528.2$……ok

CASE 4 ……OK

Stirrup Are Required

Try Ø 10 With 2 Legs whith As =157.1 mm2

$S = (Av * fyt * d)/Vs$

$= (157.1 * 420 * 287.5) / (171.13 * 10^{3})$

= 110.9mm

S max $\leq$ (d / 2) OR S max $\leq$ 600 mm

S max $\leq$ 143.75 mm OR S max $\leq$ 600 mm

S max $\leq$ 143.75………..Controlled

S max = 143.75mm > 110.9mm

TAKE S= 100 mm

USE Ø 10 With 4 Legs / 100 mm

(4-7) Design of Column (G2)):

Material:

Concrete B300 Fc' = 24Mpa

Reinforcement Steel Fy = 420Mpa

stirrup = 10 mm

Loads acting on column (G2) are as follows:

Dead Load = 1000 kN .

Live Load =500 kN.

Factored loads (Pu) = 1.4 DL = 1.4 x 1000 = 1400 kN.

OR

(Pu) = 1.2 DL + 1.6 LL = 1.2 x 1000+ 1.6 x 500 = 2000 kN ….. Cont.

Calculation of Required Dimension of Column (G2):

Total load Pu =2000 KN.

Pn = 2000 / (0.65) = 3076.9 kN

Assume ρg = 1.0 %

$Pn = 0.8 * Ag\{0.85 * fc' + \rho g(fy - 0.85fc')\}$ $3076.9 * 103$

$= 0.8 * Ag[0.85 * 24 + 0.01 * (420 - 0.85 * 24)]$ $Ag = 1572.41$ cm2

Select 60*40cm with Ag = 2400 cm².

Check Slenderness Effect:

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

$\lambda = Klu/r$

Lu: Actual unsupported (unbraced) length = 3.65 m

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

R: radius of gyration → for rectangular section =√(I/A) 0.3 h

<u>System about X</u>:

→ λ= (1*3.65)/ (0.3*0.4) =30

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

λ=30> 22

∴ long about X axis.

<u>System about Y</u>

→ λ= (1*3.65)/ (0.3*0.6) =20.3

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

λ=20.3< 22

∴ Short about Y axis.

<u>Calculate the minimum eccentricity and minimum moment</u>:

e min = 15 + 0.03 h

e min = 15 + 0.03 × 400 = 27mm.

M min= Pu* e min

M min= 3076.9*0.027=83. 1KN.m

<u>Magnification Factor:</u>

δns =[Cm/ 1 − (Pu 0.75 × Pcr)] ≥ 1.0 and ≤ 1.4

cm = 0.6 + 0.4 ∗ (M1/ M2)

cm = 0.6 + 0.4 ∗ (1) = 1.0

$$P_{cr} = \pi 2 \times (E \times I)/ (k \times L_u)$$

$$E * I = 0.4*E_c*I_g/ 1+B_{dns}$$

$$B_{dns} = 1.2\times P_D/ (1.2\times P_D+1.6\times P_L)$$

$$I_g = b(h^3)/ 12$$

$$E_c = 4700 \times \sqrt{f_c'}.$$

$$B_{dns} = 1.2* 1000/ 2000 = 0.39$$

$$E * I = 0.4 \times 4700 \times \sqrt{24} \times \{0.6 \times (0.4^3)/ 12\}/ 1 + 0.39 = 15239.7 \text{ kN.m2}$$

$$P_{cr} = \pi 2 \times 18.8 * 1000/ (1 \times 3.65) ^ 2 = 13646.1 \text{ KN}$$

$$\delta_{ns} = 1.0/ 1 - \{3076.9/ (0.75 \times 13646.1) \} = 1.37 \geq 1.0 \text{ and } \leq 1.4$$

$$e = \delta_{ns} \times e_{min} = 1.37 \times 27 = 36.99 \text{ mm.}$$

$$e_y/ h = 36.99/ 400 = 0.09$$

$$\gamma = d - d'/ h = 400 - 2 \times (40 + 10 +9)/ 400 = 0.71$$

$$\emptyset \times P_n/ A_g =\{ 2000 \times 10^3/ 400 \times 600\} \times 0.\ 145 =1.86 \text{ ksi.}$$

use Diagram A-9a (for γ=0.6), ρ_g =0.013

use Diagram A-9b (for γ=0.75), ρ_g =0.012

By use interpolation (for γ=0.71): ρ_g = 0.01227 > 0.01 …. Ok

$$A_{sreq} = \rho \times A_g =0.01227*600*400 =2944.8 \text{ mm2}$$

Select 12Ø18 with Asprov = 3054 mm2

Check spacing between the bars :

$$S = (600-2*40-2*10-5*18)/4=102.5 \text{ mm}$$

$$S = 102.5 \text{ mm } \geq 40\text{mm}$$

$$\geq 1.5d_b = 27 \text{ mm}$$

S = (400-2*40-2*10-3*18)/2=123 mm

S = 123mm ≥ 40mm

≥ 1.5db = 27 mm

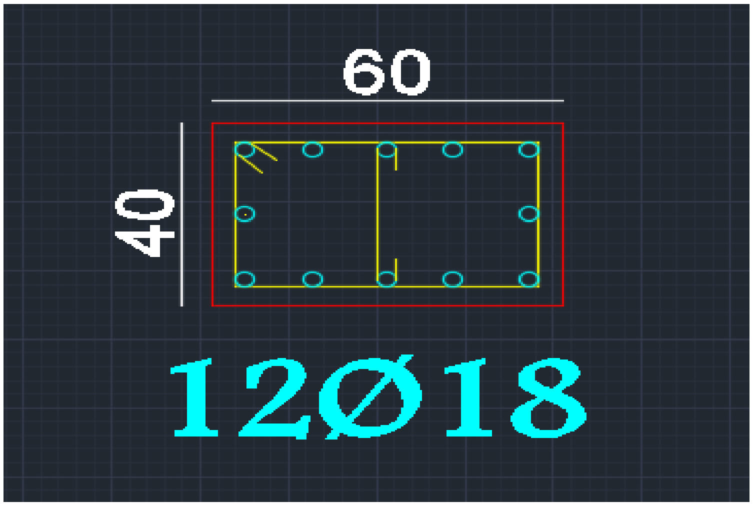


Figure (4- 13): Section of column(G2)

Design of the Stirrups:

b = 60 cm, h = 40 cm

Lap splice at the foot of column:

Try 100% - lap splice (12 Ø 18 with 12 Ø 18)

ρ =As/Ac =(24*2.54)/(60*40) =2.5% < 8 % … OK

closely stirrups :S smallest of

1-48*dbs. = 48*10 = 480 mm

2-16*db. = 16*16 =256 mm……… control ~~~selected 20cm

3- The least dimension of the column = 450 mm.

At end support and below:

X= max (Ldc OR b) + cover – (h slab or beam)

Ldc = (0.24*420*18)/ (1*√24) = 370.4mm > 200 mm … OK

→ b > Ldc → 60 cm > 37.04 cm

X= (60) + 2 – (35) = 27 cm

X > 0.5 h → 27 cm > (0.5*40) = 20 cm … OK

X< 2 h column →27 cm < 70 cm … OK

→ Selected X = 27 cm e = 8 cm → control

#NO of Stirrups = 27/8 +1 = 5

Below and above beam or slab:

Fy = 420 Map Fc = 24Mpa.

Lsc = 0.071 *420*18 = 536.76 mm > 300 mm

b =60 cm.

Selected b = 60 cm with e = 10 cm

→ Selected 7Ø**10**/**1**0 **cm**

At the points of bend:

Selected b = 60 cm<53.676 cm.

Selected b = 60 cm with e = 12 cm

→ Selected 6Ø**10**/**1**0 **cm**.

Normal Region:

Select S normal =20 cm.

(L1/20)+1 = (278/20)+1=15

→ Selected 15Ø**10**/20 **cm**.

(L2/20)+1 = (245/20)+1=14

→ Selected 14Ø**10**/20 **cm**.

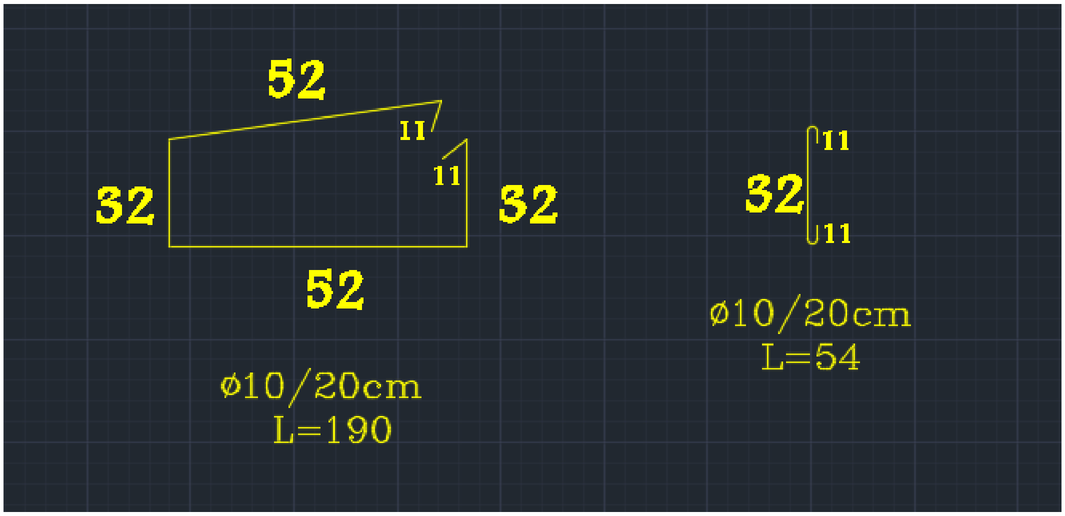


Figure (4- 14): Stirrup's detailing.

(4-8) Design of isolated footing (F1(1.45*1.45)):

Loads that act on footing

PD =500 kN PL = 250 kN

Pu = 1.2 * 500 + 1.6*250 = 1000 kN

The following parameters are used in design :

γ concrete = 25 kN/m3

γ soil = 18 kN/m3

σallow = 400 kN/m2

clear cover = 7.5 cm

fc'=28

Determination of footing dimension:

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

Assume h = 50 cm.

$\sigma b(allow)$net = 400 – 25*0.50 – 0.5*18 = 378. 5 kN/m²

$$A = \frac{P_n}{q_{a.net}} = \frac{500 + 250}{378.5} = 1.982\ m^2$$

$$l = \sqrt{A} = \sqrt{1.982} = 1.41\ m$$

Select $l = 1.45\ m$

Determination of footing depth (h):

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

$$\rightarrow \qquad q_u = \frac{P_u}{A} = \frac{1000}{1.45*1.45} = 475.62\ KN/m^2$$

Design of one way shear

Use Ø10.

d = h − $cover$ − Ø = 500 − 75 − 10 = 415mm

Vu at distance d from the face of column $V_u = q_u b(\frac{l}{2} - \frac{a}{2} - d)$

$$= 475.62 * 1.45\left(\frac{1.45}{2} - \frac{0.35}{2} - 0.415\right) = 93.1\ KN$$

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

$$= 0.75 * \frac{1}{6} * \sqrt{28} * 1450 * 415*10\text{^-3} = 398.02\ \text{kN} > \text{Vu}$$

∴ **h = 50 cm is correct ✓**

Design of Punching (two way shear)

$d = 415\ mm$

$b_\circ = 2(0.55+0.415) + 2(0.35+0.415) = 3.46$ m.

$\beta = 1.6$

$\alpha s = 40$ (interior column)

Vu = 475.62 (1.45*1.45 -(0.55+0.415)(0.35+0.415)) = 648.98kN

ØVc is the smallest of :

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

$$= \frac{1}{6}\left(1 + \frac{2}{1.6}\right) \times \sqrt{28} \times 3460 \times 415 \times 10^{-3} = 2849.29KN$$

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

$$= \frac{1}{12}\left(\frac{40 \times 659}{4836} + 2\right) \times \sqrt{28} \times 3460 \times 415 \times 10^{-3} = 4304.13\ KN$$

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

$$= \frac{1}{3} \times \sqrt{28} \times 3460 \times 415 \times 10^{-3} = 2532.7\ kN$$ ∢ **cont.**

ØVc = 0.75 × 2532.7 = 1899.53 kN > Vu = 648.98 kN

∴ **h = 50 cm is correct ✓**

Design for flexure in long direction

Mu = 475.62 *1.45*0.55*(0.0.55/2) = 104.31 kN.m

$$\mathrm{m} = \frac{Fy}{0.85 * Fc'} = \frac{420}{0.85 * 28} = 17.65$$

Mn = 104.31/0.9 = 115.9 kN.m

$$\mathrm{Rn} = \frac{\mathrm{Mn}}{\mathrm{b} * \mathrm{d}^2} = \frac{115.9 * 10^6}{1450 * 415^2} = 0.464\ \mathrm{MPa}$$

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

$$= \frac{1}{17.65} * (1- \sqrt{1 - \frac{2*0.464*17.65}{420}}) = 0.001116$$

Asreq = $\rho * b * d = 0.001116 * 1450 * 415 = 698.1$ mm^2

As (min) = 0.0018*b*h = 0.0018*1450 * 500 = 1305 mm^2

Asreq < As (min) ,

Take As = As(min)

Take 12 Ø12 ,As=1357.2 mm^2

Design for flexure in short direction

Mu = 475.62 *0.45*1.45*(0.45/2) = 69.83 kN.m

$$m = \frac{Fy}{0.85*Fc'} = \frac{420}{0.85*28} = 17.65$$

Mn = 69.83/0.9 = 77. 6 kN.m

$$Rn = \frac{Mn}{b*d^2} = \frac{77.6*10^6}{1450*415^2} = 0.311 \text{ MPa}$$

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

$$= \frac{1}{17.65} * (1- \sqrt{1 - \frac{2*0.311*17.65}{420}}) = 0.00113.$$

Asreq = $\rho * b * d = 0.00113 * 1450 * 415 = 679.98$ mm^2

As (min) = 0.0018*b*h = 0.0018*1450 * 500 = 1305 mm^2

Asreq < As (min) ,

Take As = As(min)

Take 12 Ø12 ,As=1357.2 mm^2

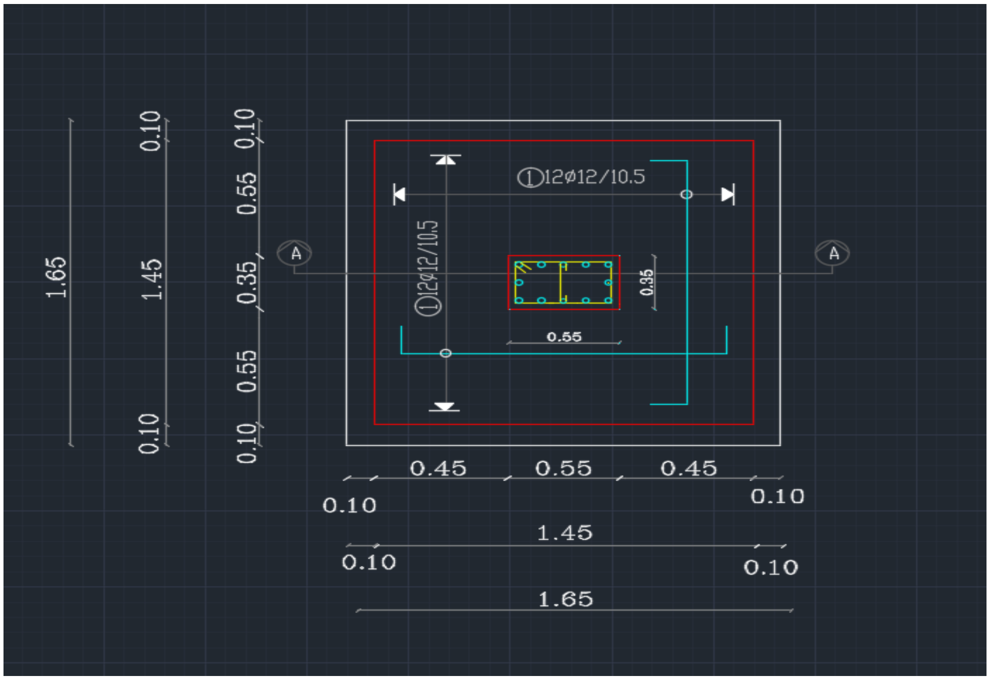


Figure (4- 15): isolated footing (F1(1.45*1.45))) detailing.

(4-9) Design Stairs

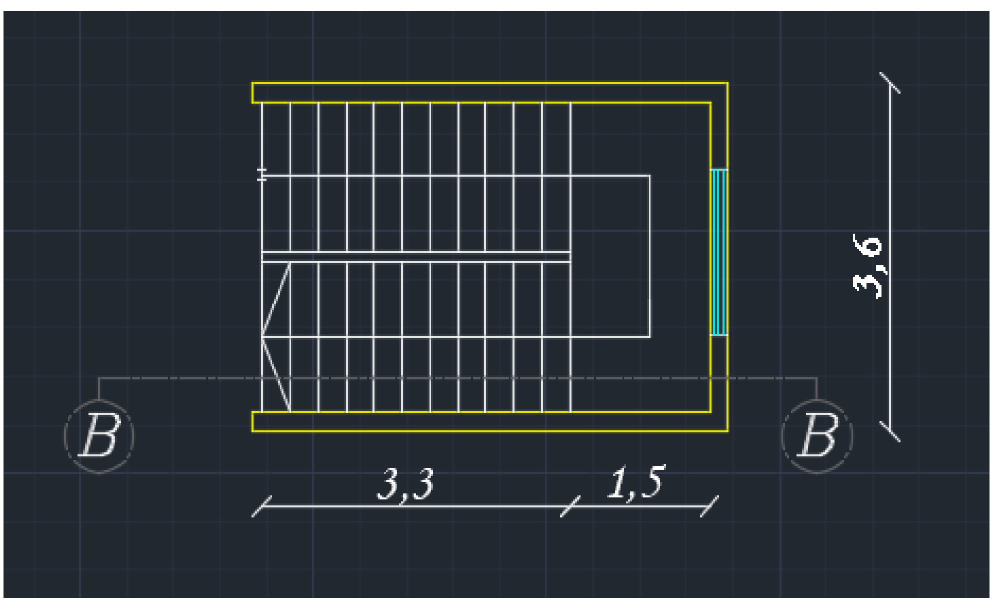


Figure (4- 16): Section of Stair.

Material :

Concrete B300 Fc' = 24 N/mm2

Reinforcement Steel Fy = 420 N/mm2

Design of Flight :

Determination of Thickness:

h min = L/20 = 4.80/20 = 24 cm .

Take h = 25 cm .

Rise =300 mm, Run =0.182 mm

The Stair Slope by θ = tan-1(18.2 / 30) = 31.24^{o}

Load Calculation

Dead Load for Flight for 1m Strip:-

No.	Parts of Flight	Calculation	
1	Tiles	22*0.03*1*((0.35+0.182)/0.3) = 1.17Kn/m	
2	Mortar	22*0.02*1*((0.3+0.102)/0.3) = 0.707Kn/m	
3	Stair	(25/0.3)*((0.182*0.3)/2) = 2.275Kn/m	
4	R.C	25*0.25*1 / cos31.24 ^{o} = 7.31Kn/m	
5	Plaster	22*0.03*1 / cos31.24^{o} = 0.772Kn/m	
		Sum	12.287Kn/m

Table (4- 4) Flight dead load computation.

Dead Load For Solid Landing For 1m Strip:-

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

Table (4- 5) Landing dead load computation.

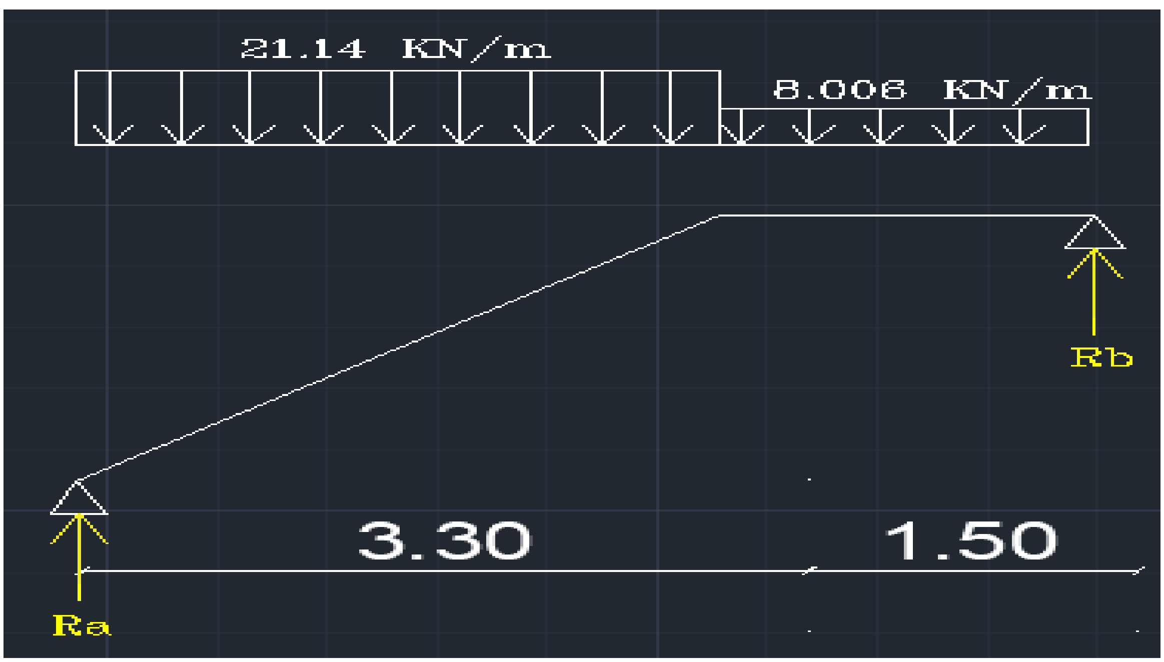


Figure (4- 17) Structural analysis of the stairs.

Live Load For Landing For 1m Strip = 4*1 = 4 Kn/m

Factored Load For Flight :- W_U = 1.2 ×12.287 + 1.6×4 =21.14 Kn/m

Factored Load For Landing :- W_U = 1.2 ×8.01 + 1.6×4 =16.012 Kn/m

Ra=52.91kn.

Rb=25.86 kn.

Deign of shear:

Assume bar diameter ø 14 for main reinforcement

d =h-cover-db/2

=250-20-14/2 = 223 mm.

Beam width = 30 cm

Vu =52.91- 8.006*(0.15+0.223) = 50.97KN

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

$$= 0.75 * \frac{1}{6} * \sqrt{24} * 1000 * 223 = 136.56 \text{ KN/1m strip}$$

Vu=50.97 < 136.56/2 =68.3 KN .

The thickness of the slab is adequate enough.

Design of Bending Moment for Flight :- (Mu=66.213 Kn.m)

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

$$Rn = \frac{Mu/Ø}{b*d^2} = \frac{\mathbf{66.213} * 10^6/0.9}{1000*223^2} = 1.48MPa$$

$$\rho = \frac{1}{m} * (1- \sqrt{1 - \frac{2*Rn*m}{Fy}}) = \frac{1}{20.6} * (1- \sqrt{1 - \frac{2*1.48*20.6}{420}}) = 0.0037$$

$$As\ req = \rho * b * d = 0.0037 * 1000 * 223 = 825.1\ mm^2/m$$

$A_{s,min}$= 0.0018*1000*250 = 450mm^2/m.

As_{req} = 825.1 mm^2>$A_{s,min}$=450mm^2/m ....OK

Select ø 14 @ 15 cm. .

Check for Spacing: -

S =3*250 =750 mm

S =450 mm

S =380*(280/274.67) – 2.5*20 =337.4 mm ……. control.

S =180 mm<337.4 -ok.

Temperature and shrinkage reinforcement :

$A_{s,min}$= 0.0018*1000*250 = 450mm^2.

Select ø 10/ 20.

Design of landing :

Mu = wl^2/8

=8.006*1.5^2/8 =2.252 KN . M

d =250-20-14-14/2= 209 mm

$$Rn = \frac{Mu/\emptyset}{b*d^2} = \frac{\mathbf{2.252}*10^6/0.9}{1000*209^2} = 0.057MPa$$

$$\rho = \frac{1}{m} * (1- \sqrt{1-\frac{2*Rn*m}{Fy}}) = \frac{1}{20.6} * (1- \sqrt{1-\frac{2*0.057*20.6}{420}}) = 0.000136$$

$$\text{As req} = \rho * b * d = 0.000136 * 1000 * 209 = 28.76 \text{ mm}^2/\text{m}$$

As req < As min .

Take As min =450mm^2

Select ø 14 / 15cm.

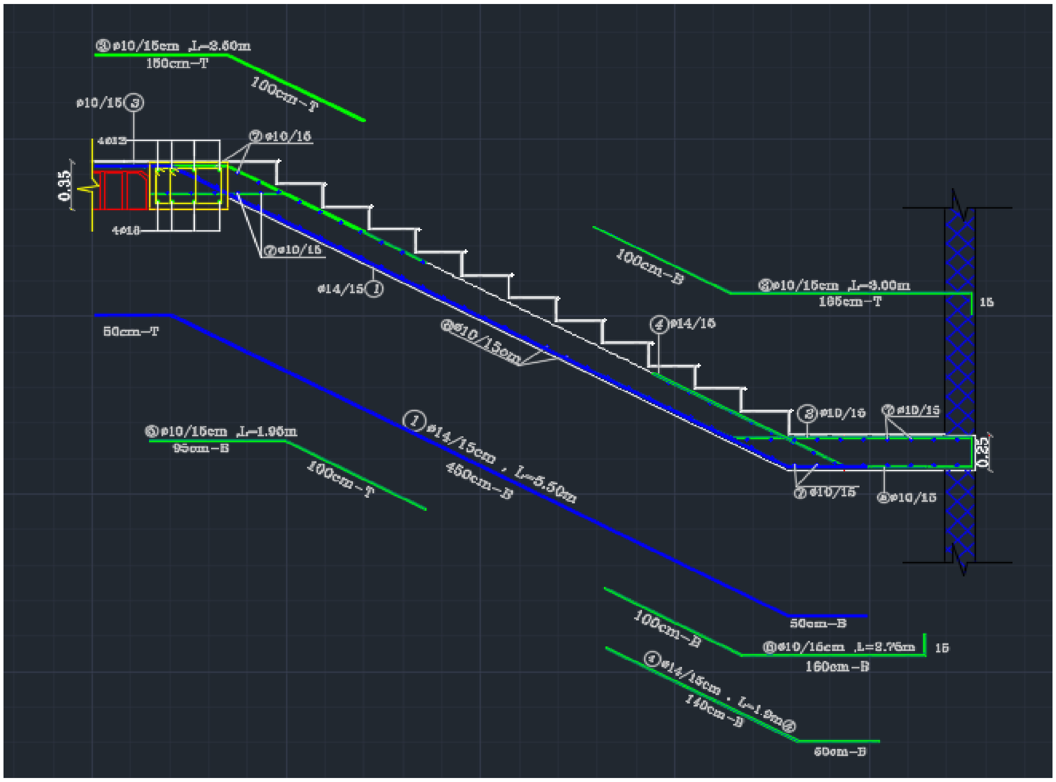


Figure (4- 18): stairs detailing.

(4-10) Design Shear walls

Analysis and design were done using ETABS program in which the seismic loads were taken into account. The following is a sample calculation for one of the walls, S.W1.

The following data that used in design:

Shear Wall thickness = h = 20 cm

Shear Wall length Lw = 5.00 m

Building height Hw=18.60 m

Critical section shear:

Lw/2=5/2=2.5 …. control

hw/2=18.6/2=9.3

story height=4.00 m

d =0.8*Lw =0.8*5.0 = 4.00 m

(4.10.1)Design of Horizontal Reinforcement

Vu = 719.17 KN.

Calculation of Shear Strength Provided by concrete Vc:

Shear Strength of Concrete is the smallest of:

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

$= \frac{1}{6}\sqrt{24} \times 200 \times 4000 = 653.2 \text{ kN} \ll \text{Controlled}$

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

$= 0.27\sqrt{24} \times 200 \times 4000 + 0 = 1058.2\ KN$

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

Where:

Mu1= 879.5 kN.m

$\frac{Mu1}{Vu} - \frac{Lw}{2} = \frac{879.5}{719.17} - \frac{5}{2} = -1.27 < 0$ → This equation is not applicable.

$\therefore Vc = 653.2 \text{ kN} \rightarrow \emptyset Vc = 489.9 < \text{Vumax} = 719.17 \text{ kN}$ →Horizontal Reinforcement is Required

$$Vs = \frac{Vu}{\emptyset} - Vc = \frac{719.17}{0.75} - 653.2 = 305.7 \text{ kN} \ \text{ needs renforcement}$$

$$\frac{Avh}{s} = \frac{Vs}{fy * d} = \frac{305.7 *}{420 * 4000} = 0.000182$$

$$\text{but } \left(\frac{Avh}{s}\right) \text{min} = 0.0025 * h = 0.0025 * 200 = \mathbf{0.5} \ll \text{Controlled.}$$

Avh : For 2 layers of Horizontal Reinforcement

Select Ø10 :

Avh = 2 *79 = 158 mm^2

$$\frac{Avh}{s} = 0.5 \rightarrow Sreq = \frac{158}{0.5} = 316\ mm \ll \text{ Controlled}$$

Smax= Lw/3 = 5000/5 = 10000 mm

= 3h = 3*200 =600mm

$= 450mm.$

∴Select Ø10 @ 200 mm at each side.

(4.10.2)Design of Vertical Reinforcement

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

$$\frac{hw}{lw} = \frac{18.6}{5} = 3.72 > 2.50$$

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

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

Smax= Lw/3 = 5000/3 = 1666.67 mm

= 3h = 3*200 =600mm

$= 450mm \ll$ Controlled.

Select $\emptyset 12$:

$$Avv = 2 * 113 = 226 \ mm^2$$

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

∴<u>Select ∅12 @ 150 mm at each side.</u>

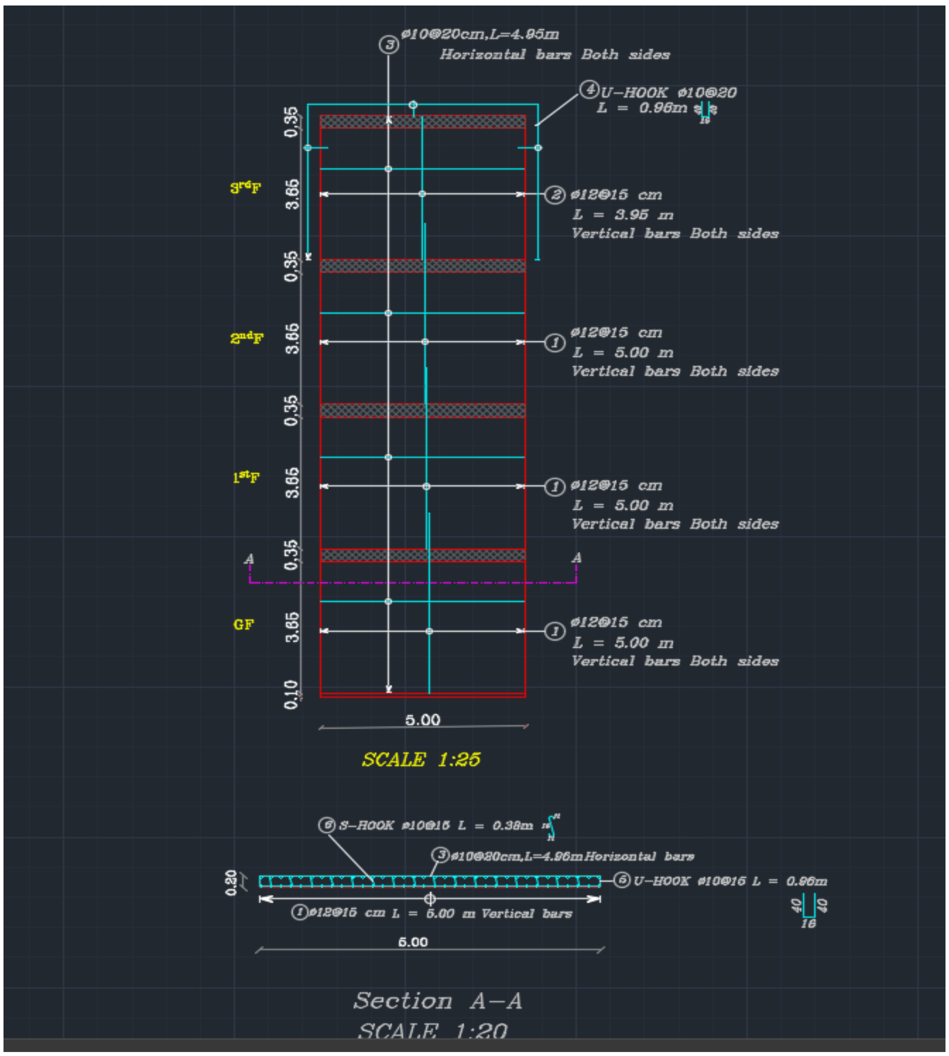


Figure (4- 19): Shear wall (S.W1) detailing.

Chapter 5
“RESULTS AND RECOMMENDATIONS”

(5-1) Introduction.

(5-2) Results.

(5-3) Recommendations.

(5-1) INTRODUCTION:

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

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

(5-2) RESULTS:

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

1. The most important step before starting a design is to study the architectural plans carefully to distribute the columns correctly.
2. Gaining experience in using structural programs cannot be reached without an understanding of basic concepts of the structural design.
4. When choosing the structural system, it is better to distribute ribs in the short direction and beams in the long one that will reduce loads that act on beams which leads to reducing of reinforcement which meant reducing costs.

(5-3) RECOMMENDATIONS:

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

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

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