Palestine Polytechnic University

Faculty of Engineering and Technology

Department of Civil Engineering and Architecture

Specialization in Civil Engineering-Building Engineering Branch

Project Name

Agriculture research center

Supervisor:

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Team:

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Humam Dabbas

Basheer Karajeh

Palestine – Hebron

2020

Project report page

Evaluation certificate graduation project page
Certification of Evaluate Graduation Project

Palestine Polytechnic University

Hebron - Palestine

Structural Design of Land of Civilizations Museum

Team:

Lama Masalmh

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Based on the instructions of Eng.Khalil Karameh and the approval of all members of the committee, this project was introduced to the department of Civil Engineering and Architecture in the Collage of Engineering and Technology for partial fulfillment of the requirements for The Bachelor Degree.

Supervisor signature	Head of the department signature
Eng. Khalil Karameh	Eng.Faydi Shabana

2020

Palestine Polytechnic University

Dedication

we dedicate this project to **God** Almighty our creator, our strong pillar, our source of inspiration, wisdom, knowledge and understanding. He has been the source of our strength throughout this program and on His wings only have our soared. we also dedicate this work to our **families** and **friends** who have encouraged us all the way and whose encouragement has made sure that we give it all it takes to finish that which we have started.To our **doctors** and **instructors** , to our **supervisor** Eng.Khalil karameh and to all who helped this to workout .

Thank you

God bless you

Lama , Humam, Basheer

Abstract

Structural Design for Agricultural Research Center

Supervision:

Eng. Fahed Salahat

Team:

Basheer Karajeh **Lama Masalmh** **Humam Dababseh**

We can summarize the aim of the project, is to work on the structural design for all elements in this edifice like slabs, beams, columns, foundations, walls and other structural elements. This project can distinguish in variety of construction methods. Mostly Is reinforcement concrete. There are different elements in this structure, such as columns, beams, slabs, etc. It contains different architecture blocks. Furthermore, this structure is comfortable and useful. it also can take large numbers of researchers and scientists.

The area of the ground and the first floors estimated to be 2400 m^2 while the second floor is estimated to be 350 m^2. In consequences the whole area of the building estimated to be 2750 m^2.
Each floor has been prepared in a way to be fully functional and ready to understand all the scientific needs and requirements such as all needed labs, offices , deposits , halls , painting and publishing rooms in the first floor .And In addition to the bedrooms , bathrooms and lunch break halls in the second floor . While the ground floor is basically for the administrative purposes such as the director room, the secretary room and the accounting room.

American concrete institute (ACI 318-14) is the reference code during project analysis and design, we will use software applications such as: AutoCAD 2016, Microsoft Office, ETABS, SAFE, Atir, SpColumn.

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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
b	width of compression face of member
Cc	compression resultant of concrete section.
Dl	dead loads.
d	distance from extreme compression fiber to centroid of tension reinforcement.
Fc	compression strength of concrete.
Fy	specified yield strength of non-prestressed reinforcement.
h	overall thickness member.
LL	live loads.
M	bending moment.
Mu	factored moment at section.
Mn	nominal moment.
Pn	nominal axial load.
Pu	factored axial load.
S	spacing of shear in direction parallel to longitudinal reinforcement.
Vc	nominal shear strength provided by concrete.
Vn	nominal shear stress.

Vs nominal shear strength provided by shear reinforcement.

Vu	factored shear force at section.
Wc	weight of concrete. (Kg/m^3)
W	width of beam or rib.
Wu	factored load per unit area.
φ	strength reduction factor.
S_c	compression strain of concrete.
S_s	strain of compression steel.
ρ	ratio of steel area.
ε_c	compression strain of concrete=0.003mm /mm
Fsd, r	total additional tension force above the support.
Ved,0	shear force at critical section.
Ned,0	normal tension force at support.
α	angel of stirrup.

Chapter 2 :

Architectural Description

2.1 Basic Identification of project

2.2 Project Site
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2.3.3 Project Sections Description

Chapter 2 :

Architectural Description

The basic aim of architecture is to make designs that are suitable for human to live , work , play in . it’s very important to make sure that the resident is comfortable and satisfied. an excellent architect understands the past talk in addition to understanding how people’s environment affect their whole life and to provide them with the desired atmosphere

Architecture, the art and technique of designing and building, as distinguished from the skills associated with construction. It requires a strong technical knowledge in the fields of engineering, logistics, geometry. Building techniques, functional design and ergonomics. It also requires a certain sensibility to arts and aesthetics. Finally, it also requires talking in consideration human questions and societies problems. Architecture is a very broad humanistic field that, at the same time, is technical artistic and social.

2.1 Basic Identification of Project

The Idea of the project is the structural design of the agriculture research center in Aroub. The center consists of three floors

1. The ground Floor : with a height of 3.37 meters and an area of 2400 m^2. . It includes of a large multipurpose hall, a general hall, six water cycles, a library, a library deposits, painting and publishing room , a raw materials room , a plant pathology library , analysis of fertilizers laboratory , plant analysis laboratory , a laboratory store ,teaching rooms, offices and a reception.
2. The first floor : with a height of 3.4 meters and an area of 2400 m^2. . it includes of meeting hall , researcher offices , conference rooms ,soil section , water section , a buffer , department of biotechnology , seed bank , feed section , animal health section , plant processing and classification room , vacuum matters room , plant drying room , plant conservation room , accounting room , personal affairs rooms , reception and rest room , director room , secretary room , vice president room , and two water cycles .
3. The third floor : with a height of 3.42 meters and an area of 350 m^2. it includes of a lunch break hall , water cycles , bedrooms and bathrooms .

.

2.2 Project Site

The site is located besides **Palestine Technical University / Kadoorie**
It is bounded by paved street from the east (Hebron – Bethlehem street / 60 street) .
Entrance to the project site is provided via the paved street from the south side. Figure (2.2) shows the site of the project and site plan is shown in architectural plans .The site land is almost rectangular shape, and covers an approximately 41000 m^2.It lies at elevation of approximately 970 m above mean sea level. electric poles and sewer pipeline were observed within the site. Its recommended that we can't build on this site, because it taken by Israeli occupation.

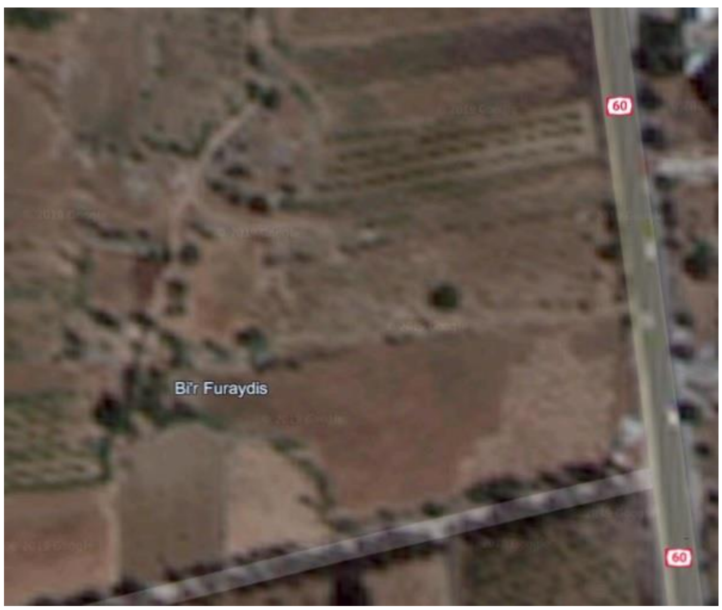


Figure 2.1: The location of the Project.

2.2.1 General climate of the Area

This area generally enjoys a Mediterranean climate of a dry summer and mild, rainy winter with occasional snowfall. The recorded average of Aroub's rainfall is about 800 mm . While the western winds dominate, the northern winds are light and the eastern winds still blow on occasion.

2.3 Project Components Description

The designer used many declines which add special architecture beauty to the structure.

2.3.1 Project Plans Description

The center has three floors with total area of 2750 m².

1. **The ground floor Plan**

   The area of this floor is 2400 m², its level is +4.45.

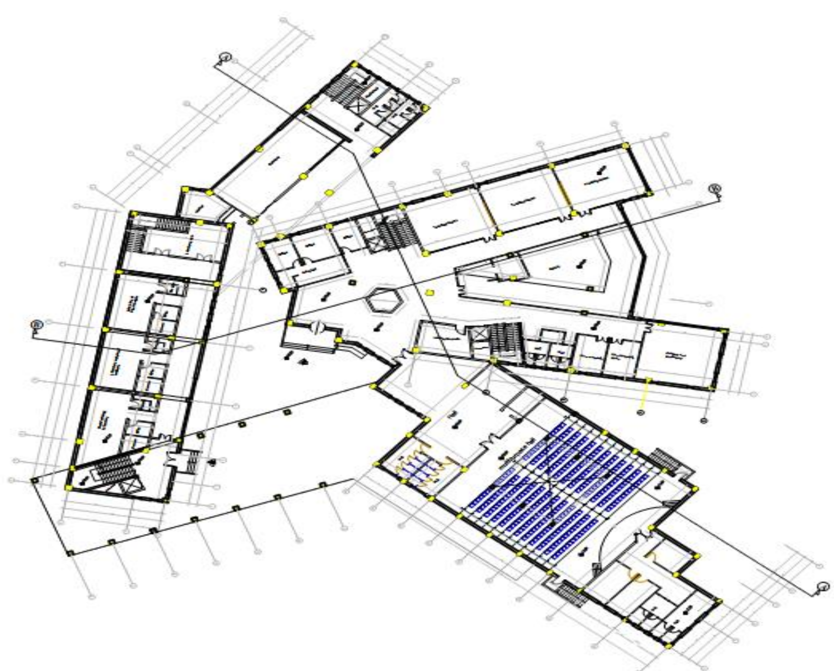


Figure 2.2: The Ground Floor Plan.

2. First Floor Plan

The area of this floor is 2400 m², its level is +8.45.

Figure 2.3: The First Floor Plan.

3. second Floor Plan

The area of this floor is 350 m², its level is +12.45 m.

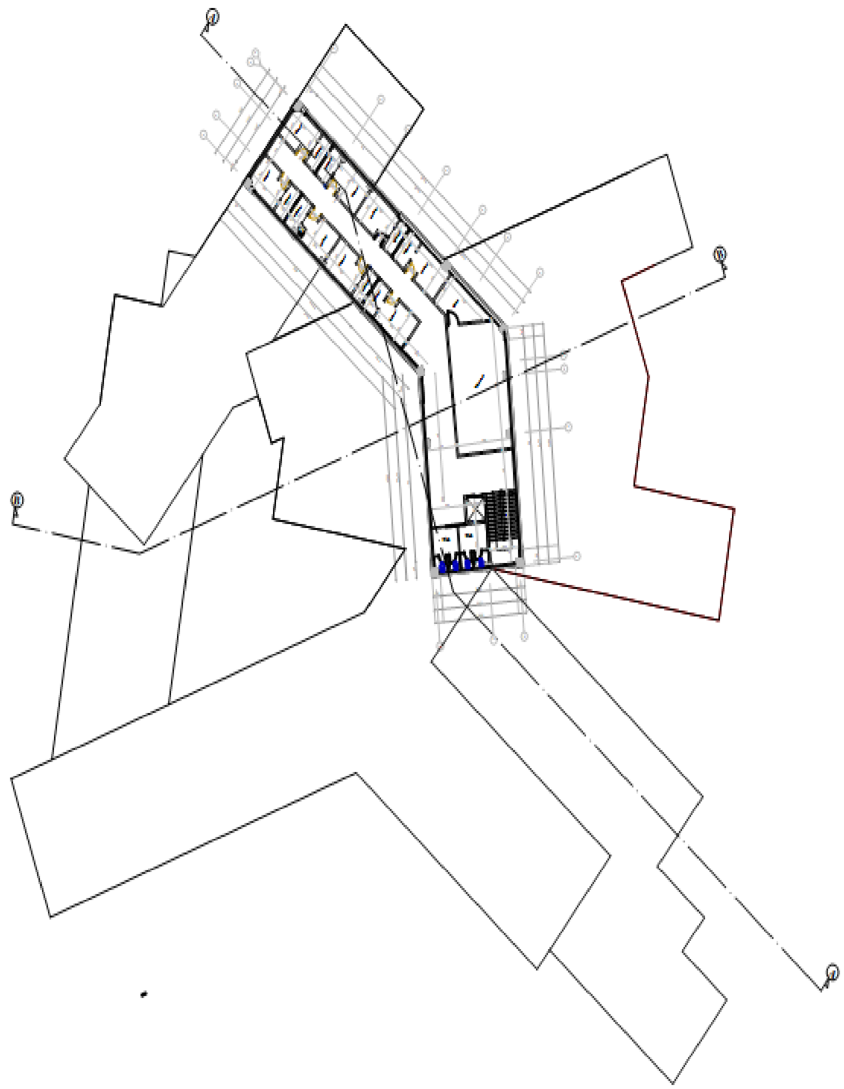


Figure 2.4: The Second Floor Plan.

2.3.2 Project Elevations Description

The interest of elevation for any architect is great as the elevation appearance should be suitable with the kind of the building and its uses, so its duty of the engineer to consider every detail of the elevations in terms of materials used, the distribution of the openings, and other factors that highlight the beauty of elevations design.

South Elevation

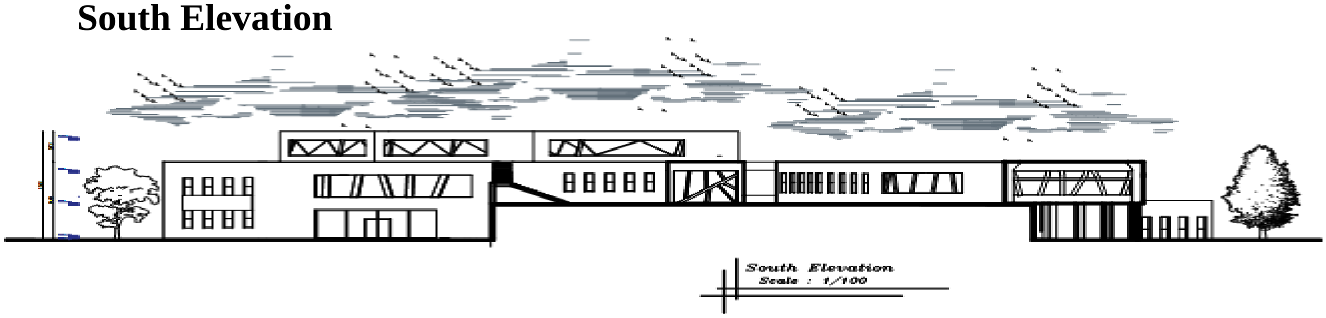


Figure 2.5: The South Elevation

East Elevation

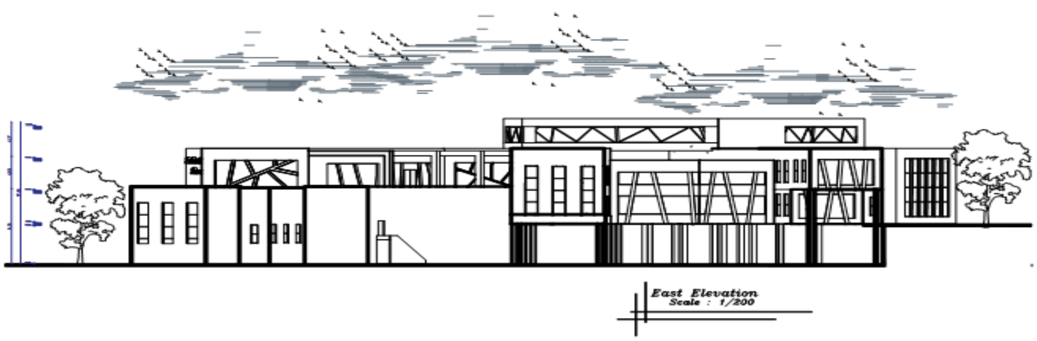


Figure 2.6: The East Elevation

West Elevation

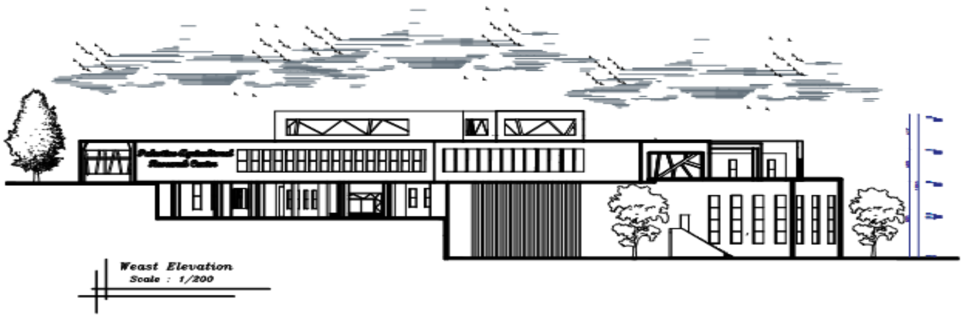


Figure 2.7: The West Elevation

North Elevation

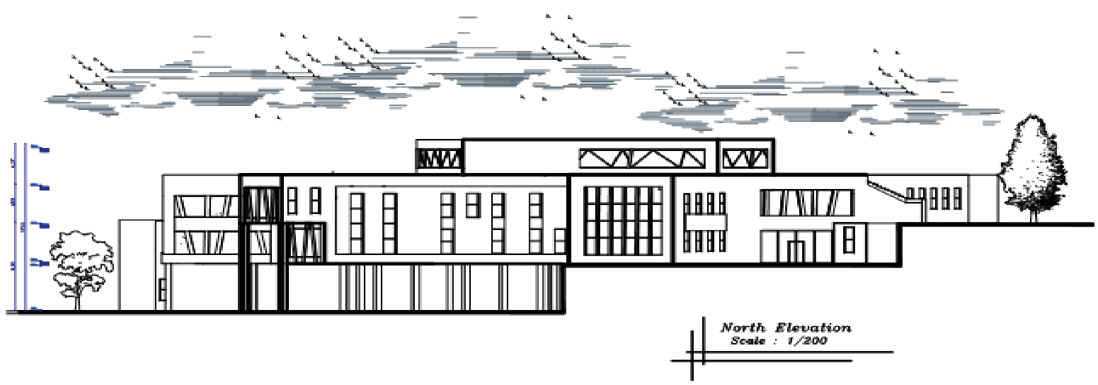


Figure 2.8: The North Elevation

2.3.3 Description of Sections

The designer distributed the movement through the horizontal and vertical axes through stairs and corridors, according to the number of users and the allowable distance between each vertical axis for easy movements between the floors and to facilitate exiting in case of emergency.

Figure 2.9: A-A Section

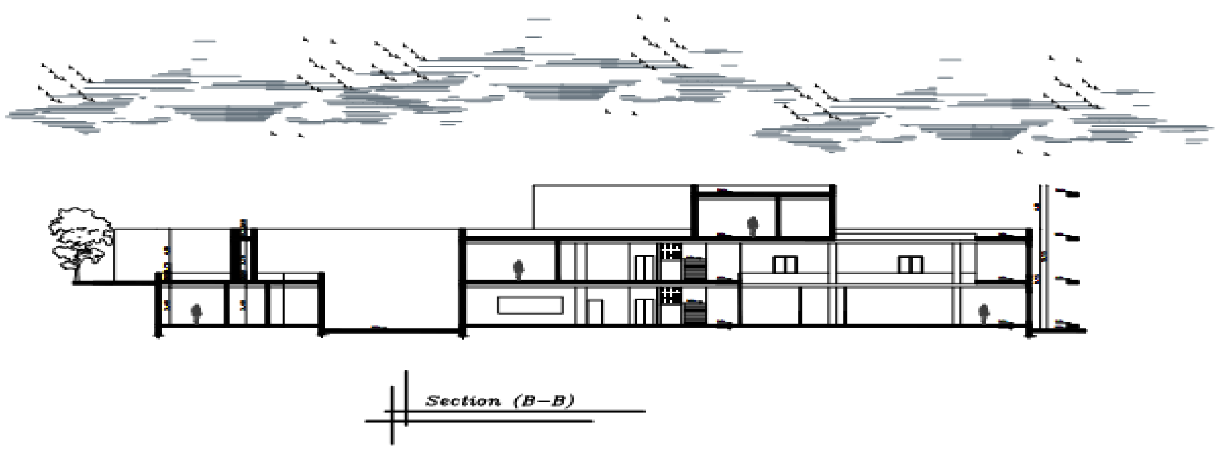


Figure 2.10: B-B section

Chapter 3:

Structural Description

After completing the process of the architectural project explanation of all the details, we must move to the construction phase of the study for the project, in order to choose the appropriate structural system for each element in the building, in order to provide all requirement and design all elements necessary for the system. So that it is taking into account the loads affecting the types of elements, showing how to deal with them and work to resist them, so we must know these structural elements in detail, in order to be customized and analyzed accurately.

3.1 The purpose of structural design

The purpose of structural design is to find the building is available where all safety requirements, in order to resist all the forces that affect the building in different forms, such as loads of dead and live or external forces such as earthquakes, wind and landing in the soil. When designing any element of these it should be taken in consideration the following standers:

1.Safety: is the essential element that must be provided in the design, so choosing the appropriate element of each region to resist loads that affecting them.

2. Economy: must be supplied when working on the selection of appropriate materials, and sufficient for its desired purpose and appropriate quantity, with lowest cost and highest quantity.

3.Serviceability: work to avoid any external failures, such as the decline in soil or any cracks in the external shape, or anything that works to increase this failure.

4.Architectural side: work to take into account the architectural elements in the building and try to keep it as much as possible.

3.2 Theoretical studies of the structural elements of the building

The most important step that should work out of the project before starting the structural design, working on a comprehensive study of the project in terms of its size the nature of its work, how to estimate the loads that effect on the building, choose items that are exposed to these loads, and identify system construction, which used to resist these loads.

3.3 Types of Loads

Loads are the base of design process, so they must have great consideration is specialty, identifying and study. Accurately, so differing building from another depends on the architectural design, project site, materials used in construction and other influences, therefore loads can be classified as follow:

1.Basic loads:

The loads which must be taken into account in the structural design of the building in all cases ,it includes: Dead load, Live load and Environmental loads.

2.Secondary loads: The loads that should be take into account in the design in some buildings, depending on the nature of the building and other influences, it includes: Shrinkage load, Thermal load, Snows load, Dynamic load, Seismic load.

3.3.1 Dead Load

These loads are permanent loads which are carried to the structure throughout their lifespan. Dead loads are also called as stationary loads. These loads occur mainly due to the self-weight of the structural members, fittings, fixed partitions, fixed equipment, etc.

Dead loads are calculated by estimating the quantity of each material and then multiplying it with the unit weight of that specific material.

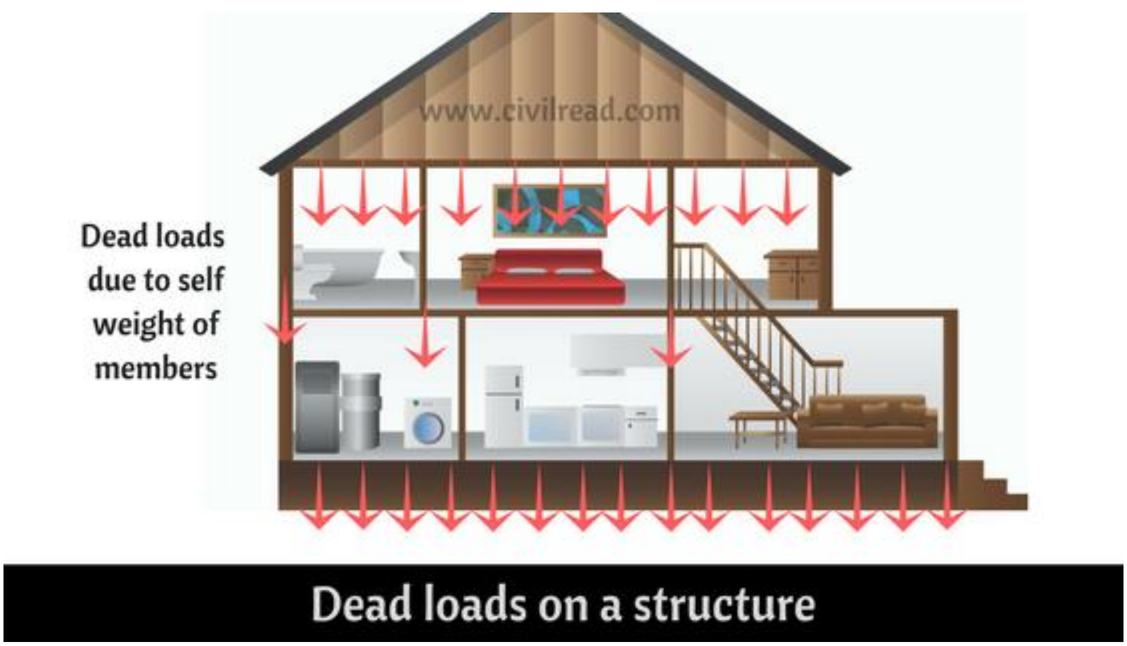


Figure 3.1 Dead Loads

Table 3.1: Specific Density of the Materials Used

Number	Material	Density(KN/m³)
1.	Tiles	23
2.	Mortar	22
3.	Sand	16
4.	Plaster	22
5.	Block	15
6.	Reinforcement Concrete	25

3.3.2 Live load

As the name itself resembling that these type of loads are real-time loads. Live loads are also called as imposed or sudden loads. Live loads changes with respect to time. This type of loading may come and go. For example, At one moment the room may be empty hence the live load is zero. If the same room is packed with the people, then the live load intensity will vary considerably. The live load includes the weight of furniture, people occupying the floor, etc.

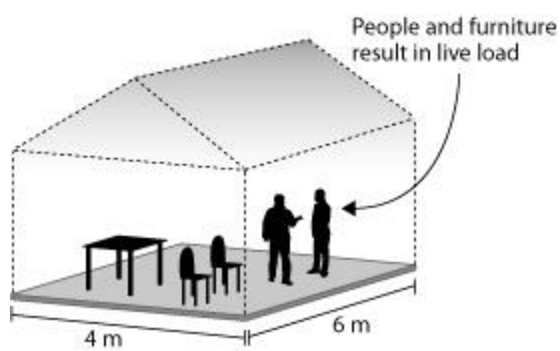


Figure 3.2 Live Loads

Table 3.2: Live Loads (Ref.: Jordan Code)

Number	Use	Live Load (KN/m2)
1.	Apartments	2.0
2.	Stairs	4.0
3.	Museums Floors	4.0
4.	Banking Halls	3.0
5.	Parking	5.0

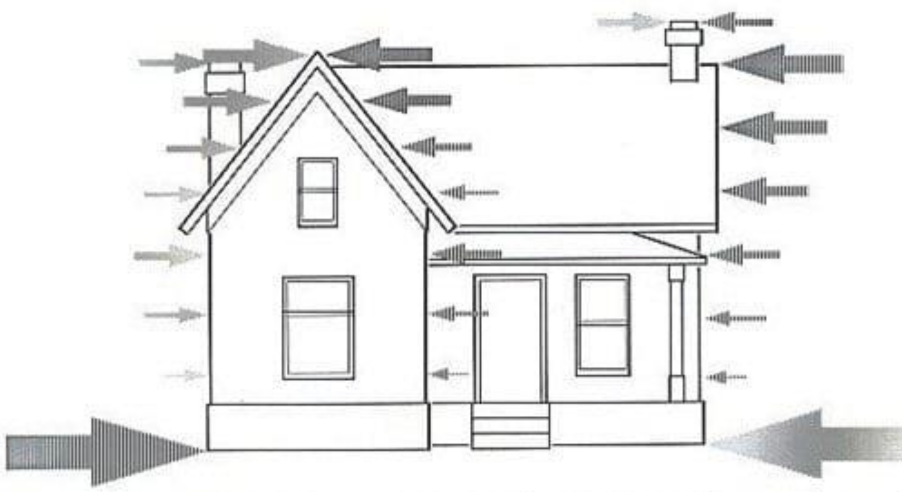
3.3.3 Environmental loads

The loads arising from the changes in the environmental such as seismic, wind and snow.

3.3.3.1 Seismic load (Earthquake load) :

These type of loads causes movement of the foundation of structures. Earthquake forces are internal forces that developed on the structure because of ground movements.

Three mutually perpendicular forces act on the structure during an earthquake, two horizontal forces which acts in opposite direction and one vertical force due to the weight of the structure. As vertical force doesn't affect much during earthquake whereas two opposite horizontal forces results in movement of the building during an earthquake. These two horizontal direction forces are considered in the design.



Horizontal earthquake forces (back-and-forth shaking) create 'whipping' forces in all parts of a building. These forces must transfer between parts of the building to the foundation.

Figure 3.3 Seismic Load

3.3.3.2 Wind load:

This types of loads are considered in design for high-rise buildings. Wind loads are occurred due to the horizontal load caused by the wind. As an increase in using lighter materials in the construction, wind load for a building should be considered. The structure should be strong enough with the heavy dead weights and anchored to the ground to resist this wind load. If not, the building may blow away. Wind load acts horizontally towards roofs and walls.

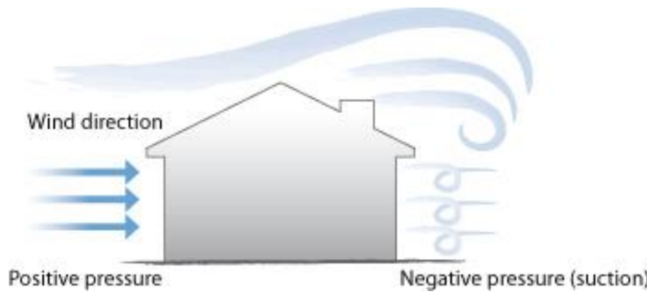


Figure 3.4 Wind Loads

3.3.3. 3 Snow load:

The building must be designed to resist snow loads and to be taken into account the design and it depends on the height of the building and the area of this building.

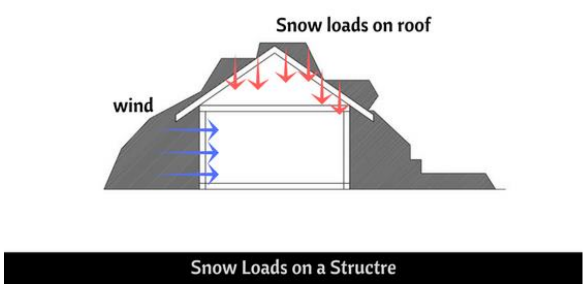


Figure 3.5 Snow Load

Table 3.3: Loads of Snow (Ref.: Jordan Code)

Building height above sea level	The value of load in surface (KN/m2)
250 > h	0
500 > h > 250	(h-250)/800
1500 > h > 500	(h-400)/320

3.4 Practical Tests

Before you begin the process of design and construction, should work some of necessary tests at the site, especially on the soil, and work to see the quality of the rocks in the region, and work to deviate place waterfalls groundwater and its impact on the building, and work to resolve the problems if available of these problems, as soil test.

3.5 Structural Elements

There are many structural elements used in the buildings as the slab, beam, column, stairs, the shear wall and foundations

3.5.1 The Slabs

Is an element which transfers the loads that are exposed to other structural elements such as column, beam, wall. They many factor to select type of slabs:

- ✦ Spacing between columns.
- ✦ Intensity of live loads.
- ✦ Architectural requirements and limitations.
- ✦ Total number of stories.

In our project, we will use Ribbed slab .

Why have we chosen one way ribbed slab ?

In our project one way ribbed slab is chosen because of many reasons :

1) In this type of slab, the tension stress is eliminated in the tension side of the slab. The strength of concrete in tension is very small and so elimination of much of the tension concrete is done by the use of pan forms.

2) Reducing the extent of foundations by reducing the ultimate load.
3) Provide architectural advantages. All the Electrical appliances can be installed easily in the gap of the ribs which can be architecturally aesthetic.
4) Economical where the live loads are fairly small such as apartment houses, hotels.

3.5.1.1 Rib Slab:

In general, this type is most commonly used in our project, this contains the steel bars use to transfer the loads, and block and the concrete between this block and the topping of all.

One way ribbed slab are used when it is intended to cover areas without bridges falling, was the use of these tiles in all floors of this project, to lightweight and effectiveness.

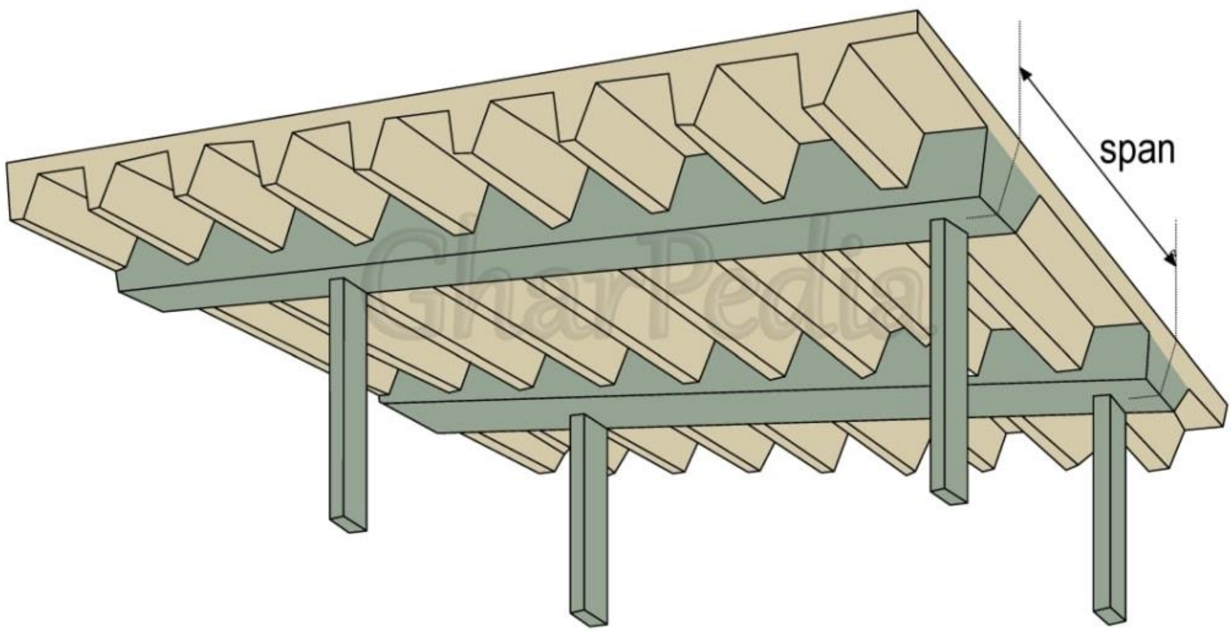


Figure 3.6 One Way Rib Slab

3.5.2 Beams

Use this element to transfer the load from the slab to the column, and have the type as hidden beam when have the same thickness of slab and drop beam when have different thickness.

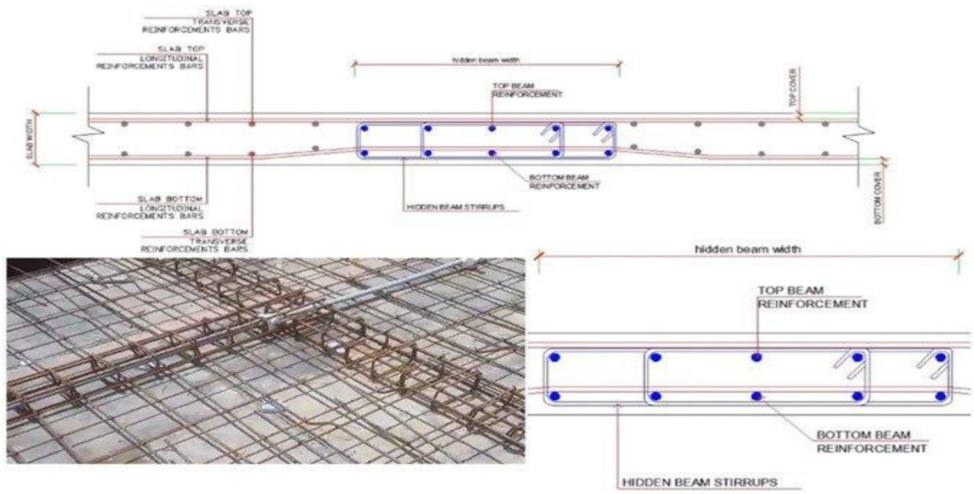


Figure 3.7 Hidden Beam.

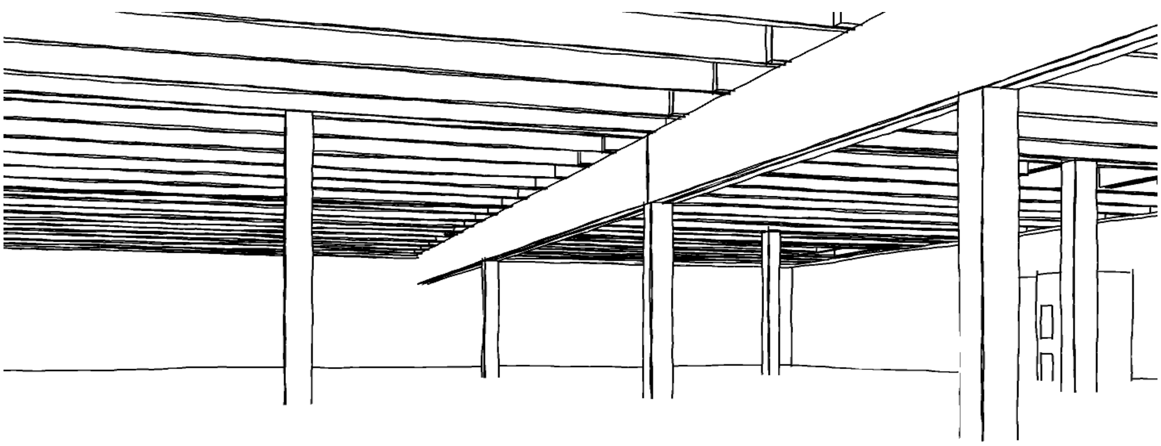


Figure 3.8 Drop Beam.

3.5.3 Columns

This element is uses to transfer the load from the slab to the foundation, and it helps in the stability of the building, and when design we will know the type design if short or slender column.

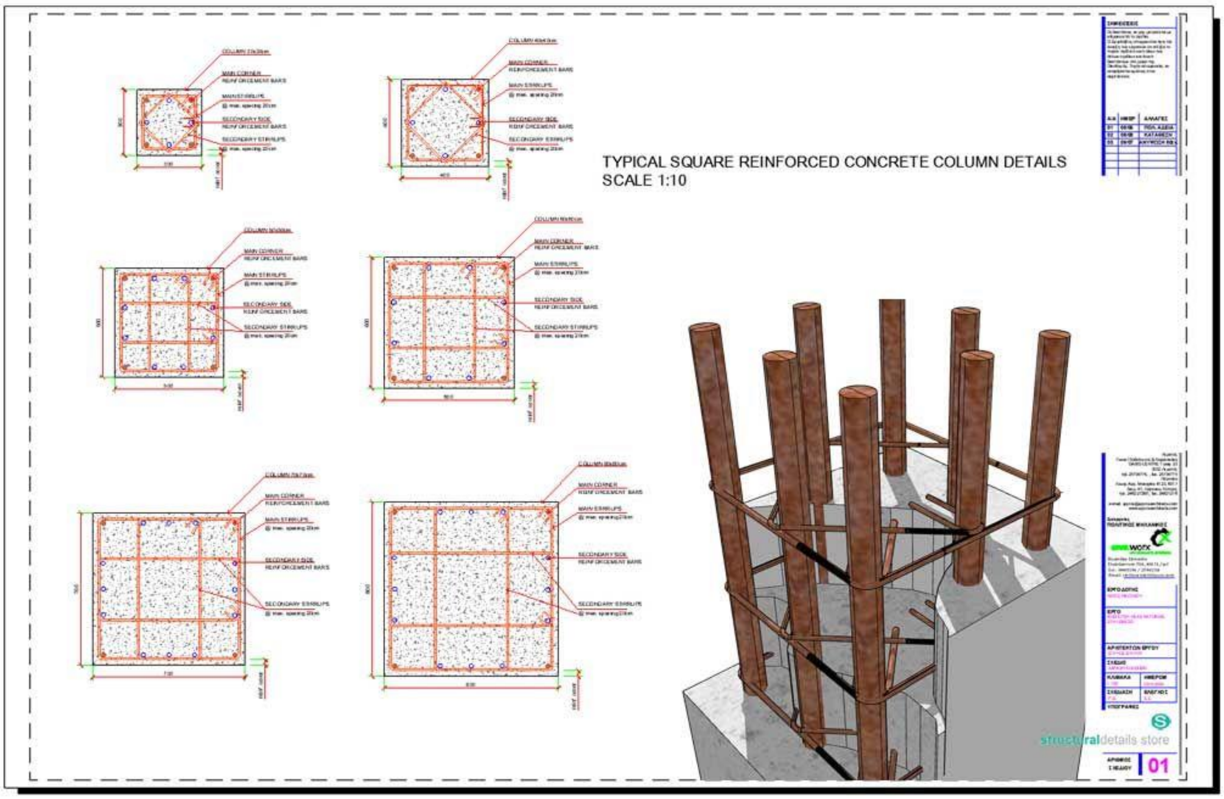


Figure 3.9 square Column.

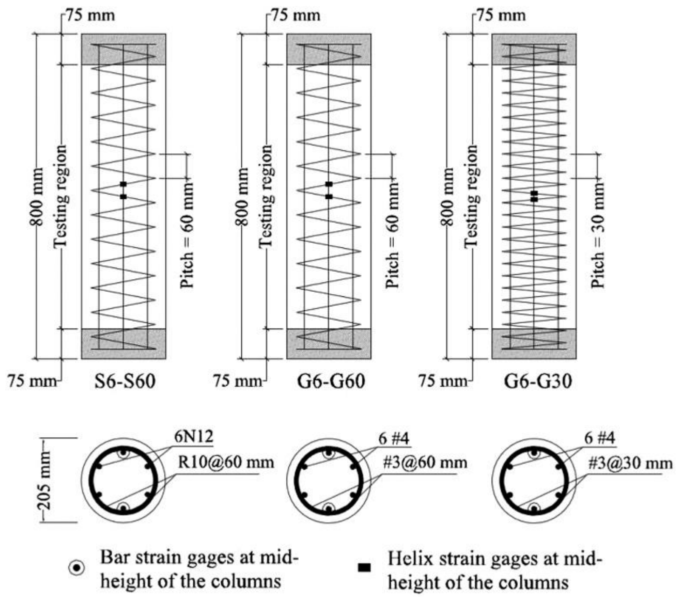


Figure 3.10 Circular Column.

3.5.4 Shear Wall

Shear wall is the important element structure because it is uses to resist the vertical and horizontal load; Shear wall is a type of structural system that provides lateral resistance to the building or structure. It resist loads as the wind and earthquake. When design this wall, we use two layer steel to give it more strength.

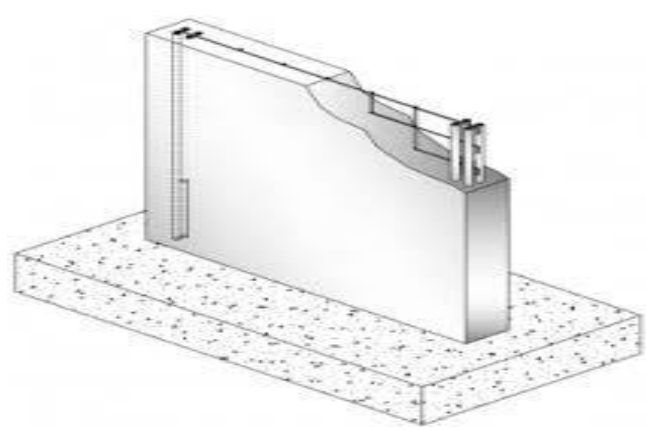


Figure 3.11 Shear wall.

3.5.5 The Foundations

The first element we implemented on the ground, but is the last element we design, because all loads are transmitted to it whether the basic load as dead or live load or secondary load. So is the basic element, which receives all the loads and distributed it to the soil.

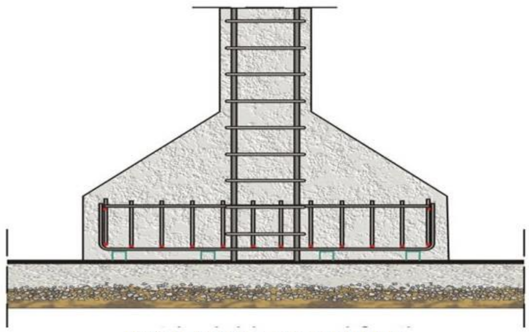


Figure 3. 12 Isolated Footing.

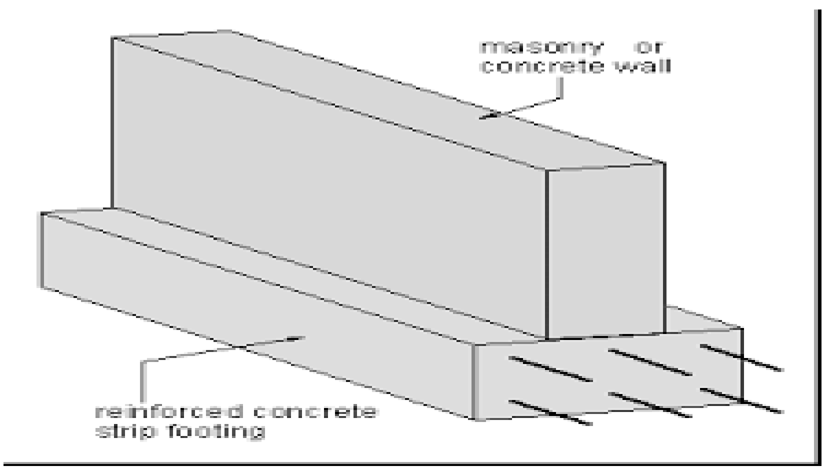


Figure 3.13 Strip Footing

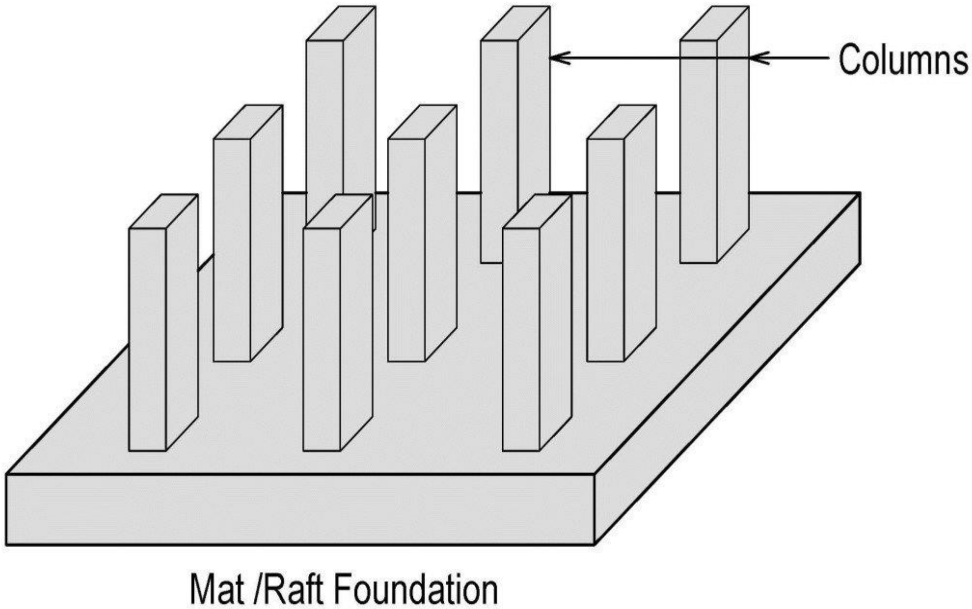


Figure 3.14 Mat Footing.

3.5.6 Stairs

The stairs is a vertical transmission element between the levels, and we used the one way solid slab in the landing structural design.

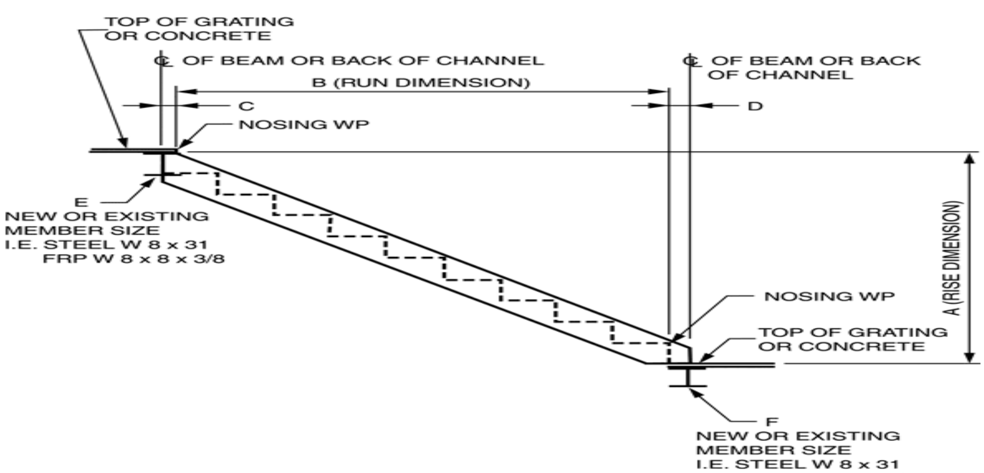


Figure 3.15 Stairs.

3.5.7 Expansion joints

Is a spacer which are used in order to avoid getting any expansion or other effects that may impair the building, where the building is separated entirely, and the building is separated after increasing distanced (35-45) m.

When you use joints must take into account the vast spaces of the building:

1. 40m areas with high humidity.
2. 36m areas with normal humidity.
3. 32m areas with medium humidity.
4. 28m with dry areas.

Chapter 4

Structural Analysis and Design

4.1 Introduction.

4.2 Materials Properties were used.

4.3 Design of Rib

4.4 Design of Beam

4.5 Design of Staircase.

4.6Design of Column

4.7 Design of Shear Wall.

4.8 Design of Isolated Footing.

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, there are two types of slabs: solid slabs and one-way ribbed. They would be analyzed and designed by using finite element method of design, with aid of a computer Program called " ATIR- Software" to find the internal forces, deflections and moments for ribbed slabs.

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

4.2 Materials Properties were used

For concrete, it was used a B300 ($fc' = 30 * 0.8 = 24MPa$) concrete compressive strength for slabs, beams and columns and B350 ($fc' = 35 * 0.8 = 28MPa$) for foundations.
For reinforcement steel, it is used a 420Mpa steel yielding strength.

4.3 Design of Rib (R20)

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

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

Slabs thickness calculation:

Determination of Thickness for One Way Ribbed Slab:

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

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

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

=688 /18.5 = **37.18 cm**

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

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

= 800/21 = **38 cm**

Select Slab thickness **h= 36cm** with **block 28 cm** & **Topping 8cm.**

Load calculations:

One-way ribbed slab:

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

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

Parts of Rib	Density	Calculation
RC. Rib	25	0.12*0.28*25= 0.84 KN/m
Top Slab	25	0.08*0.52*25 = 1.04 KN/m.
Plaster	22	0.03*0.52*22 = 0.343 KN/m.
Block	10	0.4*0.28*10= 1.12 KN/m
Sand Fill	17	0.07*0.52*17= 0.5824 KN/m
Tile	23	0.03*0.52*23 = 0.359KN/m
Mortar	22	0.03*0.52*22 =0.343 KN/m.
partition	-	2.3*0.52 =1.196 KN/m

Nominal Total Dead load = **5.823 KN/m** of rib

Nominal Total live load =3.5*0.52=**1.82 KN/m** of rib

4. 5 Design of Topping:

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

Table (4 – 1) Calculation of the total dead load on topping

No.	Material	Calculation
1	Tile	0.03*23*1= 0.69 KN/m
2	mortar	0.03*22*1= 0.66 KN/m
3	Coarse sand	0.07*16*1= 1.12 KN/m
4	topping	0.08*25*1 = 2 .0 KN/m
5	Interior partitions	2.3 *1 =2.3 KN/m
Sum		6.77 KN/m

$W_u = 1.2$ DL + 1.6 LL

= 1.2 * 6.77+ 1.6 * 3.5 = 13.724 KN/m^2. (Total Factored Load)

$$M_u = \frac{W_u * l^2}{12} = \frac{13.724 * 0.4^2}{12} = 0.183\ KN.m$$

$$M_n = f_r * S$$

$$= 0.42\sqrt{f_c'} * \frac{bh^2}{6} = 0.42\sqrt{24} * \frac{1*0.08^2}{6} * 10^3 = 2.194\ KN.m$$

$$\phi M_n = 0.55 * 2.19 = 1.207\ KN.m$$

$$\phi M_n = 1.207\ KN.m > M_u = 0.183\ KN.m$$

∴No structural reinforcement is needed

Shrinkage and temperature reinforcement must be provided.

For the shrinkage and temperature reinforcement: -

$\rho = 0.0018$

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

0f Φ8 = $\frac{As_{req}}{A_{bar}}$ = $\frac{144}{50.27}$ = 2.86 → Spacing(S) = $\frac{1}{2.86}$ = 0.349m = 349 mm.

≤ 380 ($\frac{280}{fs}$) – 2.5 * C_c ≤ 380 ($\frac{280}{fs}$)

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

= 380 * ($\frac{280}{\frac{2}{3}* 420}$) – 2.5 * 20 ≤ 380 * ($\frac{280}{\frac{2}{3}* 420}$)

= 330 mm. ≤ 380mm.

≤ 3 * h = 3* 80 = 240 mm, CONTROL!

≤ 450 mm.

∴Use Φ8 @ 20 Cm C/C in both directions.

Design of Rib (20):

Section: -

b =12cm b_f=52 cm

h =36cm T_f=8 cm

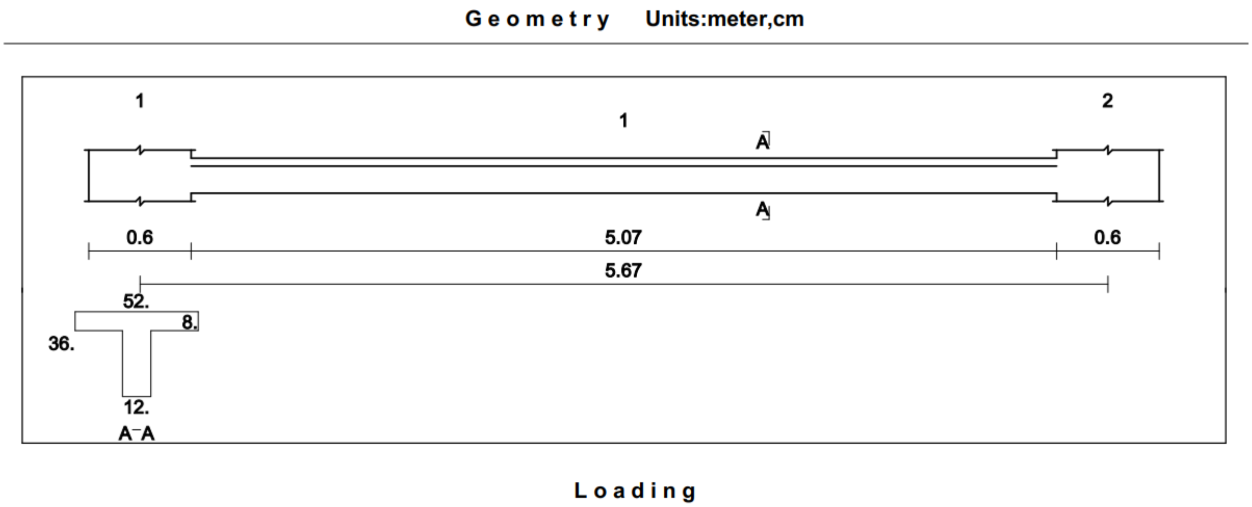


Figure (4-1): Rib geometry.

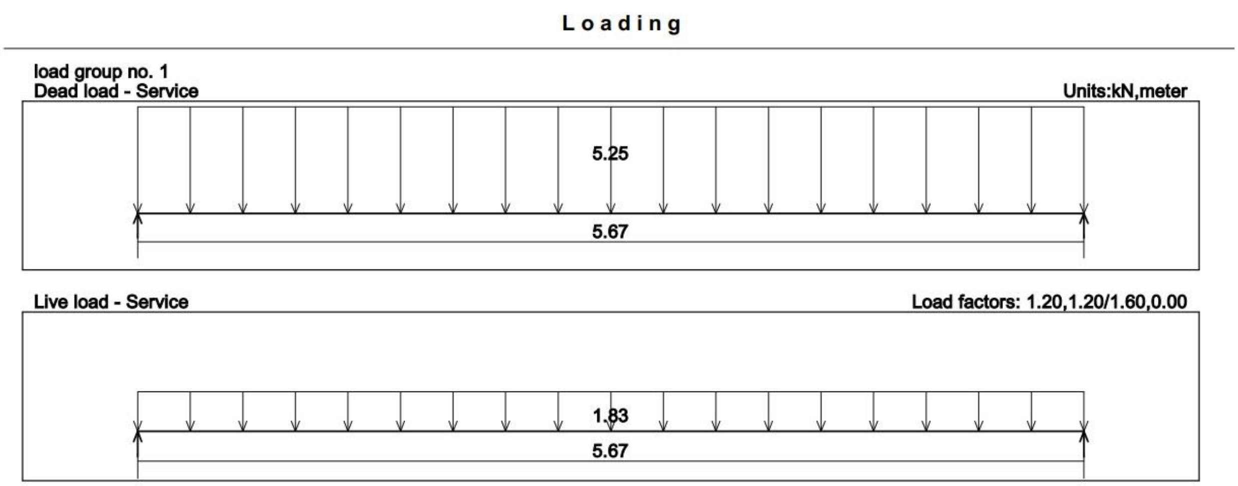


Figure (4-2): loading of rib (20)

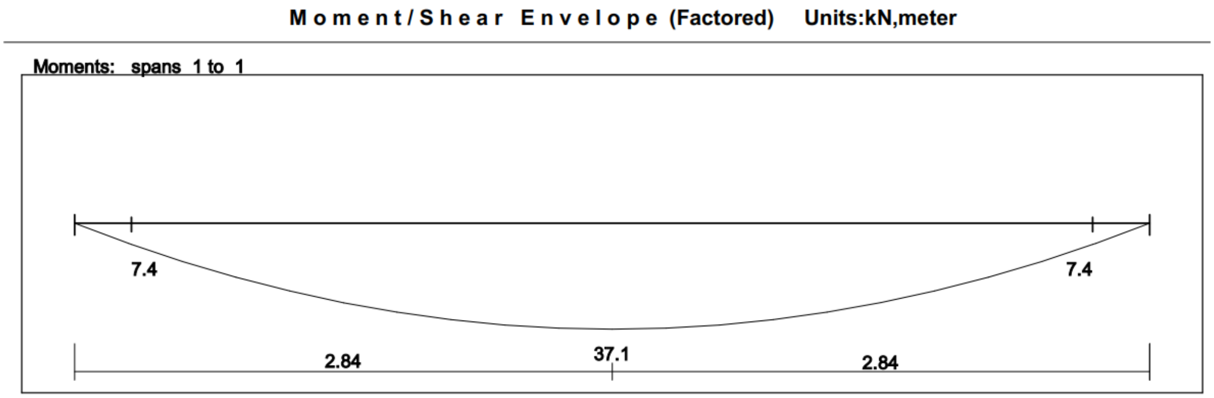


Figure (4-3): Moment Envelop of rib (62)

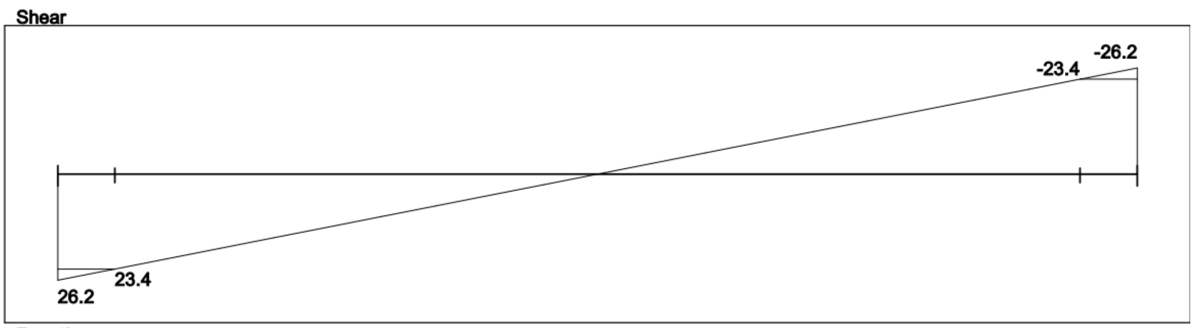


Figure (4-4): Shear Envelop of rib (62)

Design of flexure:

Design of Positive moment of rib (RIB 20):

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

= 360 – 20 – 10–$\frac{12}{2}$= 324 mm.

→$M_{u\ max}$ = 37.1 KN.m

be ≤ Distance center to center between ribs = 520 mm……….. Controlled.

≤ Span/4 = 5670/4 = 1417.5 mm.

≤ (16* t_f) + b_w =(16* 80) +120 =1400 mm.

→b_E= 520 mm.

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

$$= 0.85 * 24 * 0.52 * 0.08 * \left(0.324 - \frac{0.08}{2}\right) * 10^3 = 241.01\ KN.m$$

ϕM_{nf} = 0.9 *241.01= 216.9 KN.m

→ϕM_{nf} =216.9 KN.m> $M_{u\ max}$= 37.1 Kn.m.

∴ DESIGN AS RECTANGULAR SECTION WITH b=520mm

1) Maximum positive moment $Mu^{(+)}$ = 37.1 KN.m

M_n = Mu /ϕ =37.1/ 0.9 = 41.2 KN.m

$m = \frac{f_y}{0.85\ f'_c} = \frac{420}{0.85*24}$ = 20.58

$R_n = \frac{M_n}{b*d^2} = \frac{41.2*10^6}{520*(324)^2}$ = 0.754 MPa

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.754*20.58}{420}}\right)$= 0.00183

→$A_s = \rho$ * b *d = 0.00183* 520 * 324 = 308.31mm^2.

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

$= \frac{\sqrt{24}}{4*420} * 120 * 324 \ \geq \ \frac{1.4}{420} * 120 * 324$

= 113.37 mm^2<129.6 mm^2 ………… Larger value is control.

→As_{min} = 106.4mm^2<As_{req} = 308.31 mm^2.

∴ As = 308.31 mm^2.

2 Φ16 =402.12 mm^2>As_{req} = 308.1 mm^2 . OK.

∴ Use 2 Φ16

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

Tension = Compression

A_s * fy = 0.85 * f'_c * b * a

401.12* 420 = 0.85 * 24 * 120 * a

a = 68.81 mm.

f'_c = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{68.81}{0.85}$ =80.96 mm.

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

$= \frac{324-80.97}{80.96} * 0.003 = 0.009 > 0.005$ ∴ ϕ =0.9 … OK!

2)

∴ Use 2 Φ12 for Bottom reinforcement .

Design of shear of rib (RIB 20):

1) Vu = 23.4 KN.

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

$= 1.1 * \frac{\sqrt{24}}{6} * 0.12 * 0.324 * 10^3$ =34.91 KN.

$\phi V_c = 0.75 * 34.91$ =26.18 KN.

→Check for Cases: -

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

$23.4 > \frac{26.18}{2}$=13.1

∴ Case (1) is NOT satisfied

2- <u>Case 2:</u>

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

13.1 ≤ 24.8 ≤ 26.18 kn

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

Vs max $= \frac{2}{3} * \sqrt{f_c'} * 324 * b_w = \frac{2}{3} * \sqrt{24} * 120 * 324 * 10^{-3}$ **= 190.47 mm**

Vs′ $= \frac{Vs\ max}{2}$ **= 95.23 kn**

Vs<Vsmax … The section is large enough

Vs min=$\frac{1}{16} * \sqrt{f_c'} * b_w * d$ = 11.9

Vs min=$\frac{1}{3} * b_w * d$ = 12.96 ....**Control.**

<u>Try 2Φ8: -</u>

$\frac{100.5*420*264}{S}$ = $6.48*10^3 \rightarrow S = 2546$ mm.

$S \leq \frac{d}{2} = \frac{324}{2} = 162$mm.

≤ 600 mm.

∴ Use 2 Φ8 @ 10 Cm

4.4 Design of Beam (B- 40):

Section: -

B = 60 cm

→Select Total depth of beam **h=36cm.**

"for deflection requirements L/240"

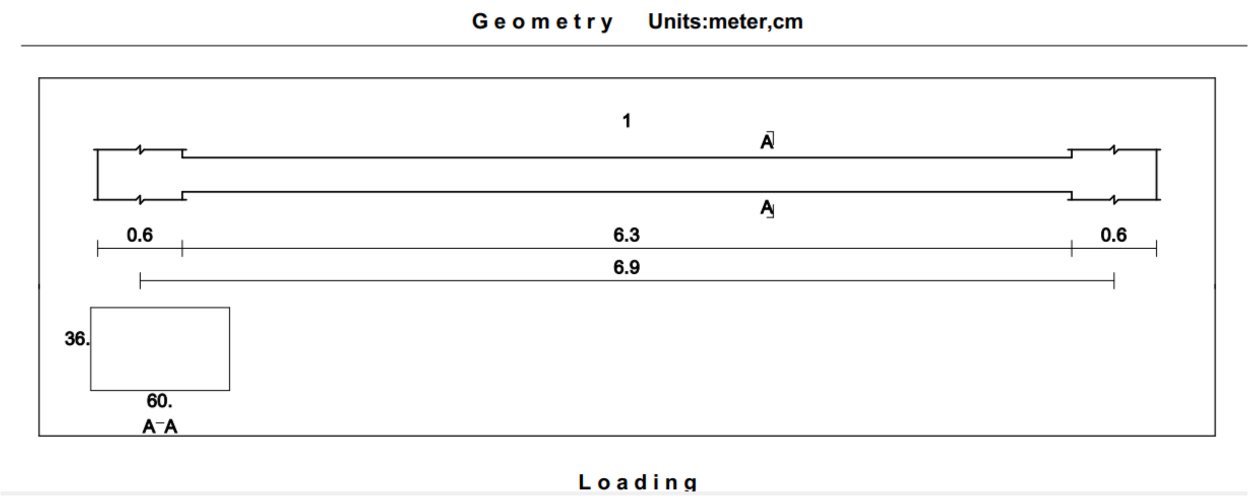


Figure (4-5): Beam Geometry.

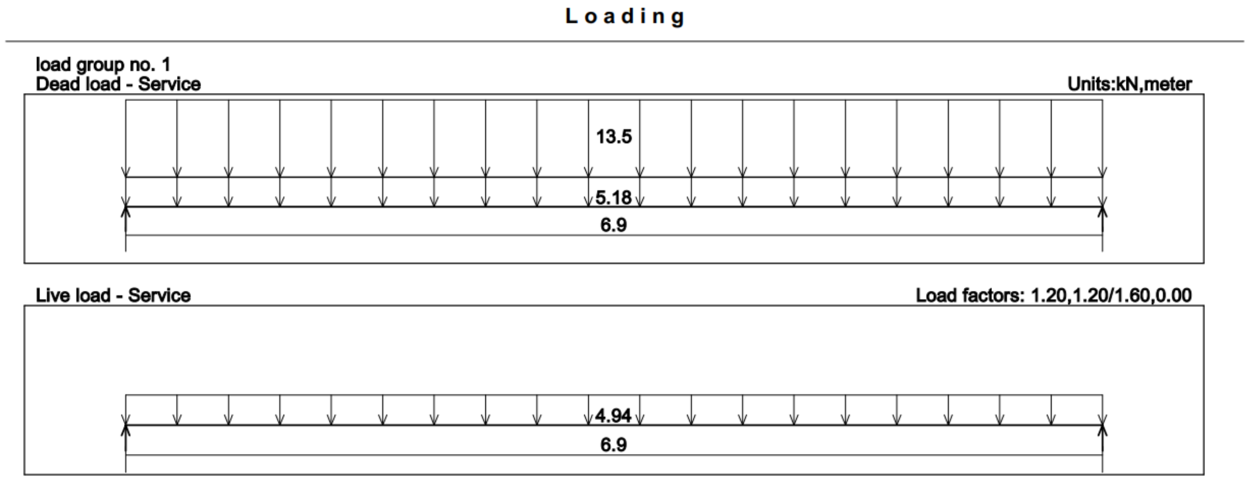


Figure (4-6): Load of Beam (B.F-40)

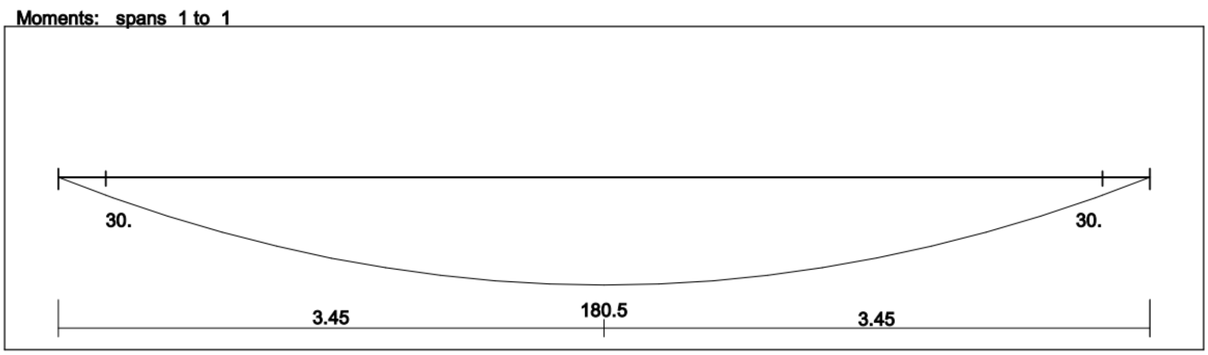


Figure (4-7): Moment Envelop for Beam (B.F-40)

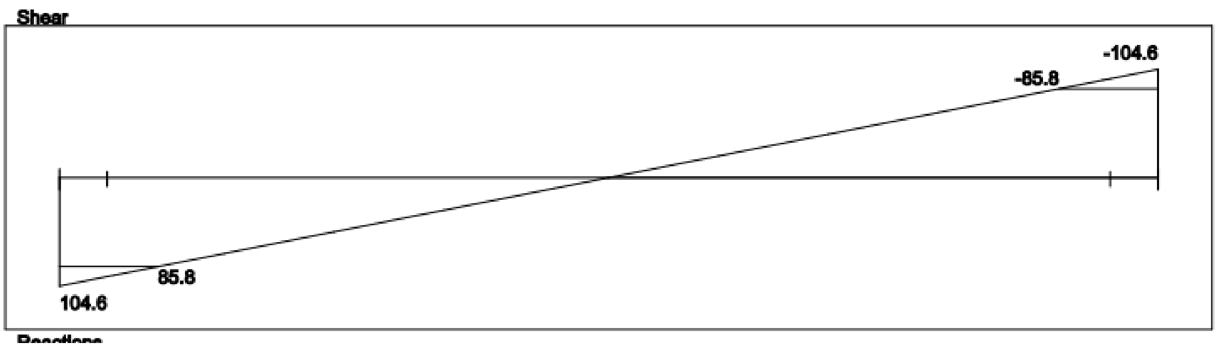


Figure (4-8): Shear Envelop for Beam (B.F-40)

Design of flexure:

Design of Positive moment:

→Mu_{max} =180 KN.m

b= 80 Cm.   h =36 Cm.

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

=360 – 40 – 10 – $\frac{18}{2}$ =301mm

C_{max} = $\frac{3}{7}$ * d = $\frac{3}{7}$ * 301 =129 mm.

f_c' = 24 MPa < 28 MPa→β_1 = 0.85

a_{max} = β_1* C_{max} = 0.85 * 129= 109.65 mm.

*Note:

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

= 0.85 * 24 * 600* 109.65 * (301 – 109.65/2) * 10^{-6}

=330.39 KN.m

ϵ_s = 0.004

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

→ϕMn_{max} = 0.82 * 330.39=270.92 KN.m

→ Mu = 180 KN.m< ϕMn_{max} 270.92KN.m

∴Singly reinforced concrete section.

1) Maximum positive moment $Mu^{(+)}$ = 180.5 KN.m

Mn = Mu /ϕ= 180.5/ 0.9= 200.55KN.m .

→m=20.6

$R_n = \frac{M_n}{b*d^2} = \frac{200.55*10^6}{600*(301)^2}$ =3.689 MPa

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

$\frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*3.689*20.6}{420}}\right)$=0.01

$A_s = \rho * b * d = 0.01*600*301 = 1806 mm^2$

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

$$\frac{\sqrt{24}}{4 * 420} * 600 * 301 \geq \frac{1.4}{420} * 600 * 301$$

$=526.63\ mm^2 < 602 mm^2$ …. Larger value is CONTROL

As= 1806 mm^2

Use Φ25…. As=490.87mm^2

∴ **Use 4 Φ25…As=1963** > 1806 mm^2

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

Tension = Compression

$A_s * fy = 0.85 * f'_c * b * a$

1963* 420 = 0.85 * 24 * 600 * a

a = 67.35 mm.

$f'_c = 24$ MPa< 28 MPa→ $\beta_1 = 0.85$

$c = \frac{a}{\beta_1} = \frac{67.35}{0.85} = 79.24$mm.

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

$= \frac{301-79.24}{79.24} * 0.003 = 0.008 > 0.005$ ∴ ϕ =0.9 … OK!

Design of shear: -

1) Vu = 85.8 KN .

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

$= 0.75 * \frac{\sqrt{24}}{6} * 600 * 301 * 10^{-3} = 110.6$ KN.

→ **Check For dimensions: -**

$\phi Vc + (\frac{2}{3} * \phi * \sqrt{f'_c} * b_w * d) = 110.6 + (\frac{2}{3} * 0.75 * \sqrt{24} * 0.8 * 0.301 * 10^3)$

$= 700.4$ KN > Vu = 85.8 KN.

∴ Dimension is adequate.

→ **Check For Cases: -**

1- Case1 : $V_u \leq \frac{\phi V_c}{2}$.

$85.5 \leq \frac{110.6}{2} = 55.3$ .... Not SATISFIED!

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

55.3 <85.5 ≤110.73 …. SATISFIED!

∴ Use 4 Φ12 @ 15 Cm

$Vc = \frac{216.04}{0.75} = 288.05KN$

$= (\frac{233.2}{0.75} - 288.05) = 22.88$ KN.

Try 2Φ10 =2 * 78.5 = 157 mm^2.

$\frac{2*135.7*}{S} = \frac{11.68 * 10^{-3}}{(420 * 441)} \rightarrow s = 1270.96mm$

$s \leq \frac{d}{2} = \frac{301}{2} = 150mm$ …. CONTROL

≤ 600 mm.

\∴ Use Φ12 @ 15Cm 2L.

4.6 Design of Staircase:

Minimum slab thickness:

Minimum slab thickness for deflection is (for simply supported one-way solid slab):
$h_{min} = L/20$

$h_{min} = 7/20 = 35$ cm

Take h = 35 cm

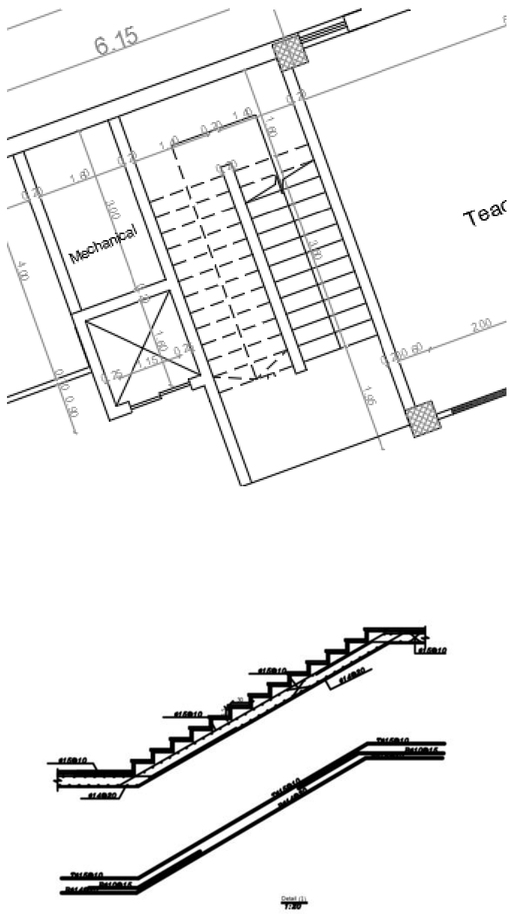


Figure 4. 1: Staircase Dimensions

4.6.2 Load Calculation:

Load: the applied live loads are based on the plan area (horizontal) projection, while the dead load is based on the sloped length to transfer the dead load into horizontal projection.
The Stair Sloped by $\theta = \tan^{-1}(\text{riser / run})$

$= \tan^{-1}(15.5 / 30) = 29.85^{o}$

- Flight dead load computation:

Table 4. 4: Flight Dead Load Computation

Parts of Flight	Quality Density kN/m^3	Calculation of(W) kN/m
Tiles	**27**	27 * 0.03 * 1 * ((0.35+0.155)/0.3) = 1.36
Mortar	**22**	22 * 0.03 * 1 * ((0.35+0.155)/0.3) 1.001
Stair Steps	**25**	(25/0.3) * ((0.155 * 0.3)/2)) *1 = 1.39
R.C Solid Slab	**25**	25 * 0.3 * 1 / ($\cos 27.32^o$) = 8.44
Plaster	**22**	22 * 0.03 * 1 /($\cos 27.32^o$) = 0.75
Total Dead Load		**13.48 kN/m**

Landing dead load computation:

Table 4.5: Landing Dead Load Computation.

Parts of Flight	Quality Density kN/m^3	Calculation of(W) kN/m
Tiles	**23**	23 * 0.03 * 1 * = 0.69
Mortar	**22**	22 * 0.03 * 1 * = 0.66
R.C Solid Slab	**25**	25 * 0.3 * 1 = 7.5
Plaster	**22**	22 * 0.03 * 1= 0.66
Total Dead Load		**9.51 kN/m**

- Live Load: LL = 3.5 kN/m^2.
- Total factored load: w = 1.2 DL + 1.6 LL

For flight w = 1.2 * 13.48 + 1.6 * 3.5 * 1 = 21.7766 kN/m^2.
For landing w = 1.2 * 9.51 + 1.6 * 3.5* 1 = 17.012 kN/m^2.

Because the load on landing, where the shear wall surrounding it, is carried into two directions, only half the load will be considered in each direction (17.012 / 2 = 8.506 kN/m).

4.6.3 Design of slab S1:

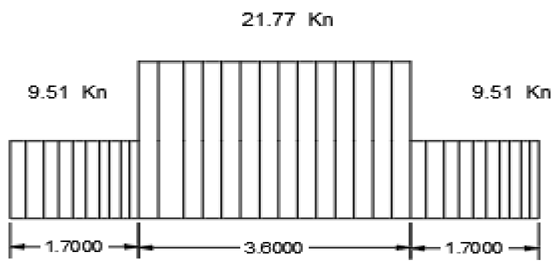


Figure 4. 2: Stair Loading.

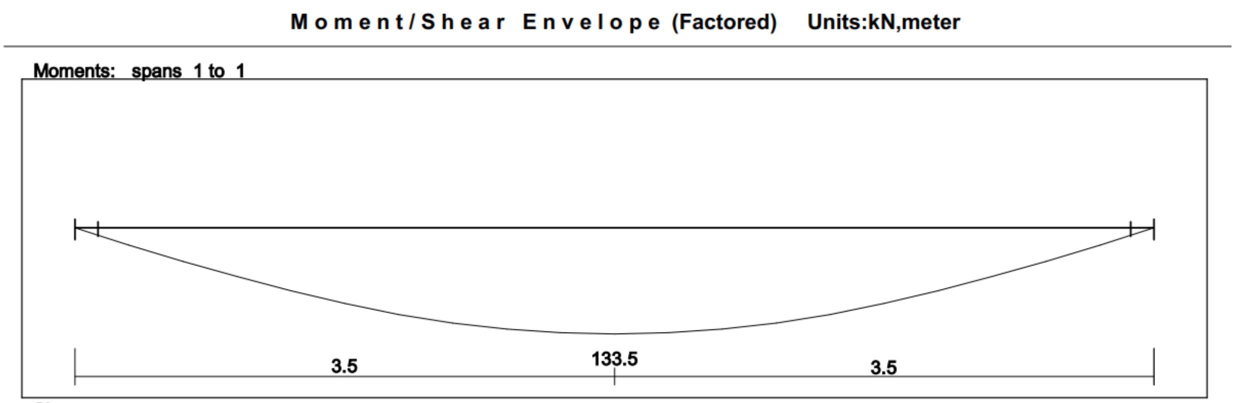


Figure 4. 3: Stair Bending Moment Diagram.

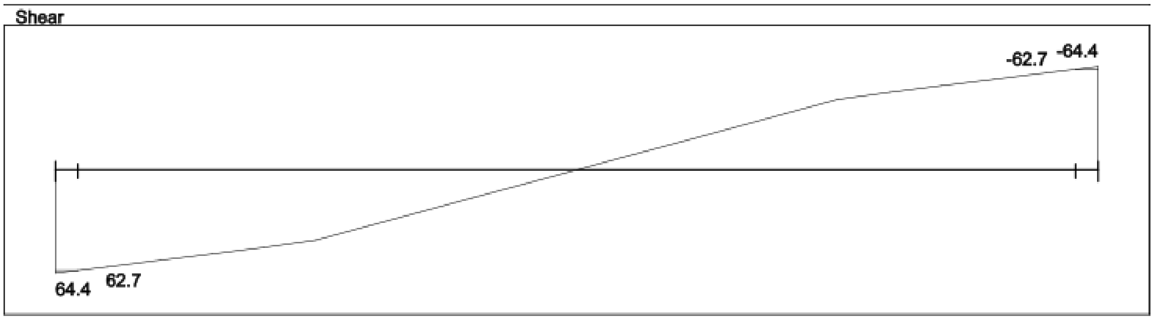


Figure 4. 4: Stair Shear Force Diagram.

4.6.3.1 Check for shear strength:

Assume initial bar diameter Ø14 $for\ main\ reinforccment$, Φ = 0.75 $for\ shear$

Assume bar diameter Ø14 for main reinforcement

d =h- cover $-\frac{d_b}{2} = 350 - 20 - \frac{14}{2} = 323\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d = = \ \frac{1}{6}\sqrt{24} * 1000 * 323 = 263.72$ kN.

Φ V_c = 0.75* 263.72 = 197.79 kN

197.79 kN > Vu = 62.7 kN**,** the slab thickness is adequate enough.

4.6.3.2 Design the flight for bending moment:

Mu=133.5 kN.m

$R_n = \frac{M_u}{\emptyset bd^2} = \frac{133.5\times10^6}{0.9\times1000\times323^2} = 1.42Mpa$

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

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2\times20.6\times1.42}{420}}\right) = 0.0035$

$A_{s,\ req}$ = ρ.b.d = 0.0035 ×1000×323 = 1134.4 mm^2/m

$A_{s,\ min}$= 0.0018*1000*360 = 630 mm^2/m

$A_{s,\ req}$ = 1134.4 mm^2>$A_{s,\ min}$=630mm^2/m

Check for which maximum spacing is control:

1. S = 3h = 3*360 =1080 mm

2. S = 380*($\frac{280}{\frac{2}{3}*420}$) – 2.5*20 = 330 mm **OR** 300 * ($\frac{280}{\frac{2}{3}*420}$) =300 mm control

3. S = 450 mm

- S = 300 mm is control
- Use Ø16 @200 mm, $A_{s,\ provided}$= 1206.3 mm^2 > $A_{s,\ required}$= 1134.4 mm^2……………… Ok
-

Check for strain:-

a =$\frac{A_{s}.f_y}{0.85b\ f_c'} = \frac{1134.4\times420}{0.85\times1000\times24} = 23.35\ mm$

c= $\frac{a}{\mathcal{B}_1} = \frac{23.35}{0.85} = 27.47\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{323-27.47}{27.47}\right) = 0.035 > 0.005 \ldots\ldots\ldots\ldots\ldots.\boldsymbol{0k}$$

Temperature and shrinkage reinforcement:

$A_{s,\ req}$= $A_{s,\ min}$ =0.0018*1000*350 = 630mm^2

4.6.4 Design of slab S2 (landing):

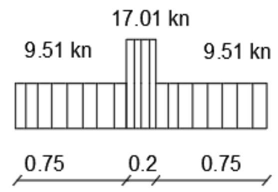


Figure 4. 5 Landing Loading

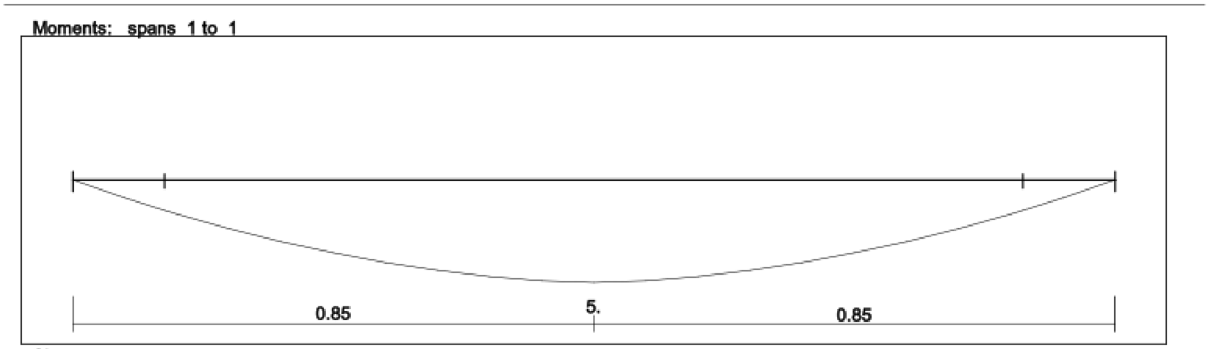


Figure 4. 6: Landing Bending Moment Diagram.

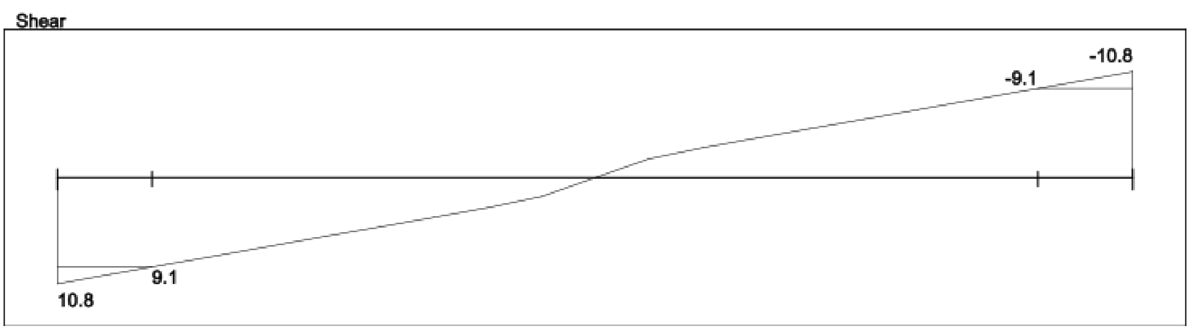


Figure 4. 5: Landing Shear Force Diagram

4.6.4.1 Check for shear strength:

Assume bar diameter ø 14 for main reinforcement

d =h- cover $-\frac{d_b}{2} = 350 - 20 - \frac{14}{2} = 323\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d = = \ \frac{1}{6}\sqrt{24} * 1000 * 323 = 263.72$ kN

$\Phi * V_c = 0.75 * 263.72 = 197.7$ kN

197.7KN > Vu = 9.1 kN**,** the slab thickness is adequate enough.

4.6.4.2 Design the landing for bending moment:

Mu=13.3 kN.m

$R_n = \frac{M_u}{\emptyset bd^2} = \frac{9.1 \times 10^6}{0.9 \times 1000 \times 273^2} = 0.1\ Mpa$

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

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 0.1}{420}}\right) = 0.00027$

$A_{s,req}$ = ρ.b.d = 0.00027 ×1000×323 = 74.71 mm^2/m

$A_{s,min}$= 0.0018*1000*350 = 630mm^2/m

$A_{s,req}$ = 74.71 mm^2 < $A_{s,min}$=630mm^2/m, use $A_{s,min}$=630mm^2/m.

Check for which maximum spacing is control:

1. S = 3h = 3*350 =1050 mm
2. S = 380*$(\frac{280}{\frac{2}{3} * 420})$ – 2.5*20 = 330 mm **OR** 300 * $(\frac{280}{\frac{2}{3} * 420})$ =300 mm control
3. S = 450 mm

- S = 300 mm is control, use Ø12 @ 150 mm, $A_{s,\ provided}$= 791.6 mm^2 > $A_{s,\ required}$= 630 mm^2…… Ok

Temperature and shrinkage reinforcement:

$A_{s,req}$= $A_{s,min}$ =0.0018*1000*350 = 630mm^2

Use Ø12 @ 150mm, $A_{s,\ provided}$= 791 mm^2 > $A_{s,\ required}$= 630mm^2 ………… Ok

4.7 Design of Column 1 (Group 1):

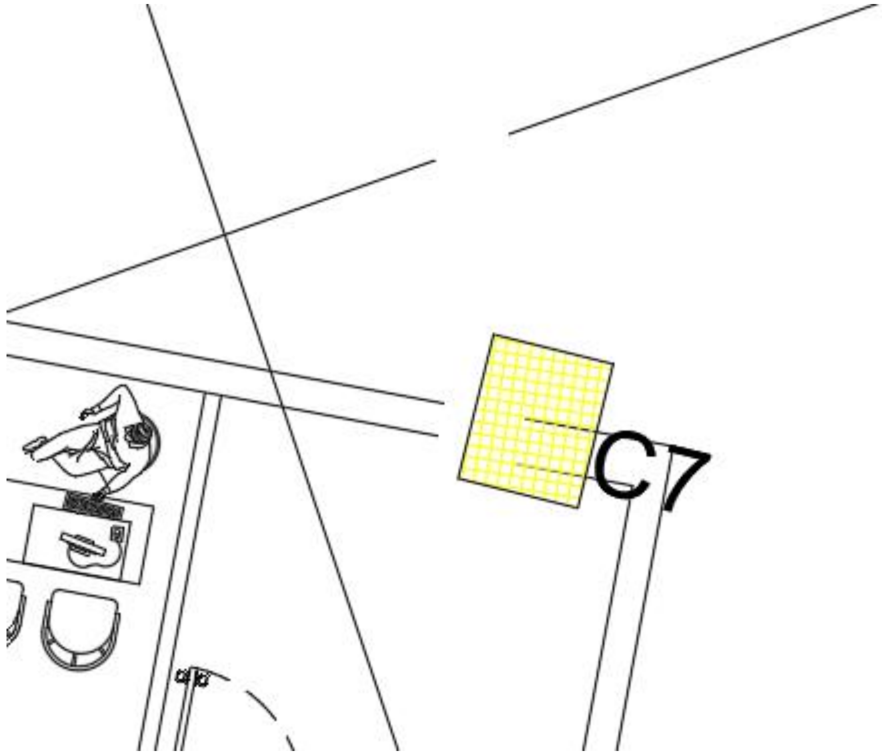


Figure (4-12): Location of Column

4.7.1 Load Calculation

Service Load: -

Dead Load = 2380 KN
Live Load = 1020 KN

Factored Load: -

P_U = 1.2 × 2380 + 1.6 ×1020 = 4488 KN

4.7.2 Column Dimensions

$Assume \rho g = 0.01$

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

$4488*1000 = 0.65 \times 0.8 \times Ag \{0.85 * 24 (1 - 0.01) + 0.01 * 420\}$

Ag= 353865 mm2

Assume Rectangular Section

Try h = 750 mm

b = 900 mm

Ag=675000 mm^2

Selecting Longitudinal Bars:
$4488*1000 = 0.65 \times 0.8 \times \{0.85 * 24\ (675000 - Ast) + Ast * 420\}$
Ast= 12690mm^2

Use 26 ø 25, Ast(prov) = 12762.7mm^2 > Ast=12690mm^2

ρg = Ast/Ag = 0.01

4.7.3 Design of Tie reinforcement

S ≤16 db. (longitudinal bar diameter)

S≤ 48dt (tie bar diameter).

S ≤ Least dimension.

spacing $\le 16 \times d_b = 16 \times 2.5$ =40 cm Control

spacing $\le 48 \times dt = 48 \times 1.0$ = 48 cm

spacing ≤ least. Dim = 75cm

Use ø 10@20 cm

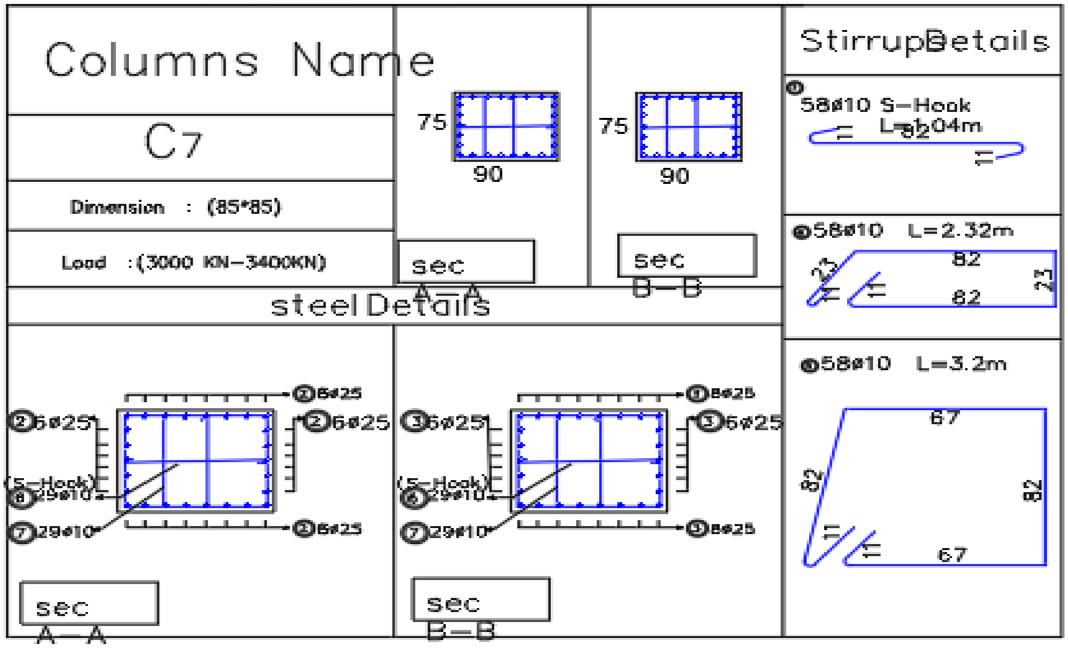


Figure (4-13): Detailing of Column

4.8 Design of Shear Wall:

4.8.1 <u>Shear wall general information:</u>

⇒ Shear Wall Thickness h = 30 cm

⇒ Shear Wall Width Lw = 6.00 m

⇒ Shear Wall Height Hw =3.75 m

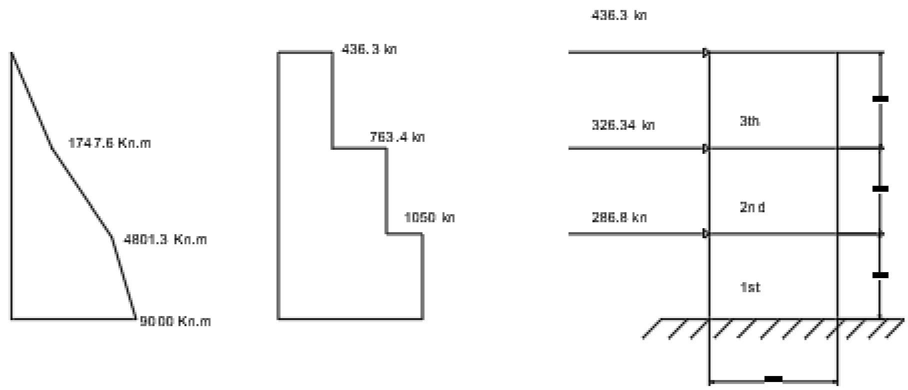


Figure 4. 6: Shear Wall Dimensions and Loads .

4.8.2 <u>Check for shear strength:</u>

4.8.2.1 Maximum shear strength permitted:

$\emptyset V_{nmax} = \emptyset \frac{5}{6}\sqrt{f_c{}'}hd$, d = 0.8$L_w$ = 0.8*6 = 4.8m.

$= 0.75 * 0.83 * \sqrt{24} * 480 * 6 \ = 8783.89\ kN$ > $V_{u,\ max}$ = 612 kN.

4.8.2.2 Shear strength provided by concrete Vc:

Critical Section for shear is the smaller of:

$\frac{lw}{2} = \frac{6}{2} = 3m - control$

$\frac{hw}{2} = \frac{12.5}{2} = 6.25m$

Story height = 4 m.

$V_c$is the smallest of :

$1-\ V_c=\frac{1}{6}\sqrt{f_c{}'}hd=\frac{1}{6}\sqrt{24}*300*4.8=1175.75KN$ …….. Control

$2-\ V_c=0.27\sqrt{f_c{}'}hd+\frac{N_u d}{4l_w}=0.27\sqrt{24}*300*4.8+0=1904.7KN$

$$3-\ V_c=\left[0.05\sqrt{f_c}+\frac{l_w\left(0.1\sqrt{f_c{}'}+0.2\frac{N_u}{l_w h}\right)}{\frac{M_u}{V_u}-\frac{l_w}{2}}\right]hd$$

$\Longrightarrow M_u=1747.92+326*(3-2.65)=1862.02kN.m$

$\frac{M_u}{V_u}-\frac{l_w}{2}=\frac{1862.02}{612}-\frac{6}{2}=0.4$ <1, so the previous equation does not available to apply for shear calculations.

- Determine required horizontal shear reinforcement:

$Vu=612>\frac{1}{2}Vc=\frac{1}{2}*0.75*1175.75=440.9kN$ …. reinforcement is required.

Shear reinforcement must be provided in accordance with 11.9.9.

Assume Ø10 for shear reinforcement.

$Vu\le ØVn=Ø(Vc+Vs)$

$Vs=\frac{Vu}{Ø}-Vc=\frac{612}{0.75}-1175.75=\ -359.75, use\ minimum\ ratio\ of$ $\rho_t = 0.0025$

Minimum shear reinforcement is required,

Maximum spacing is the least of:

$\frac{Lw}{5}=\frac{6000}{5}=1200\ mm.$

$3h=3*300=900\ mm.$

$450\ mm-control.$

Select Ø10, two layers:

$\rho_t=\frac{Avh}{hS_2}=\frac{2*78.5}{300*S_2}=0.0025$

So that S_2 =209.4 mm < 450, Take Ø10@200mm in both sides.

- Determine vertical shear reinforcement:

$\frac{h_w}{Lw}=\frac{12.25}{6}=2.04$

$\rho_l=[0.0025+0.5\left(2.5-\frac{h_w}{Lw}\right)(\rho_t-0.0025)]\ge 0.0025$

$=[0.0025 + 0.5(2.5 - 2.04)(0.0025 - 0.0025)] \geq 0.0025$

So, ρl = 0.0025.

Maximum spacing is the least of:

$\frac{Lw}{5} = \frac{6000}{5} = 1200\ mm.$

$3h = 3 * 300 = 900\ mm.$

$450\ mm - control.$

Select Ø10 @ 200 mm.

4.8.3 <u>Design of shear wall for flexure:</u>

Uniformly distributed flexure reinforcement method was followed.

The uniformly distributed vertical reinforcement Ø10 @ 200 mm

$A_{st} = \left(\frac{6000}{200}\right) * 2 * 78.5 = 4710\ mm^2$

$w = \left(\frac{A_{st}}{L_w h}\right)\frac{f_y}{f_c'} = \left(\frac{4710}{6000 * 300}\right)\frac{420}{24} = 0.045$

$$\alpha = \frac{P_u}{l_w h f_c'} = 0$$

$$\frac{C}{l_w} = \frac{w + \alpha}{2w + 0.85\beta_1} = \frac{0.045 + 0}{2 * 0.045 + 0.85 * 0.85} = 0.066$$

$\emptyset M_n = \emptyset\left[0.5 A_{st} f_y l_w (1 + \frac{P_u}{A_{st} f_y})(1 - \frac{c}{l_w})\right]$

$= 0.9[0.5 * 4.710 * 420 * 6.000(1 + 0)(1 - 0.066)] = 4988.62\ kN.\text{m} > 2460\ kN.m$

Vertical reinforcement provided is enough.

4.10 Design of Isolated Footing: (Footing Group 7)

Material:
Concrete B300 Fc' = 24 kN/m^2
Reinforcement Steel Fy = 420 kN/m^2

4.10.1 Load Calculations:

Dead Load =2397.5 kN “included own weight”

Live Load = 1020 kN

Total services load = 1020 + 2397.5 = 3417.5 kN

Total Factored load = 1.2*2397.5 + 1.6*1020= 4509 kN

Column Dimensions (a*b) = 75*90 cm

Soil density = 17 Kg/cm3

Allowable Bearing Capacity = 400 KN/m2

Assume h = 70cm

$$q_{net-allow} = 400 - 25 * 0.7 - 17 * 1.3 = 360.4\ KN/m^2$$

4.10.2 Area of Footing:

$$A = \frac{P_{total\ service}}{q_{net-allow}} = \frac{3417.5}{360.4} = 9.48\ m^2$$

Assume Square Footing

b required = 3.08m

Select b = 3.08m

Take 3.1

Bearing Pressure:

$$q_{u,net} = \frac{P_{total\ factored}}{A} = \frac{4509}{3.1 * 3.1} = 469.2\ KN/m^2$$

4.10.3 Design of Footing:

4.10.3.1 Design footing for one way shear:

Critical Section at distance (d) from face of column.

Assume h = 700cm, bar diameter Ø 12 for main reinforcement and 7.5 cm Cover.

d = 700 – 75 – 12 = 613 mm

Vu = $q_u * \left(\frac{B-a}{2} - d\right) * L$

Vu = $469.28 * \left(\frac{3.1-0.75}{2} - 0.613\right) * 3.1$

$= 817.5\ KN$

$\emptyset V_c = 0.75 * 0.17 * \sqrt{f'_c} * b_w * d$

$\emptyset V_c = 0.75 * 0.17 * \sqrt{24} * 3100 * 613 * 10^{-3}$
$= 1186.96\ KN$

$\emptyset V_c > V_u$ ⋙⋙⋙⋙ *okay*

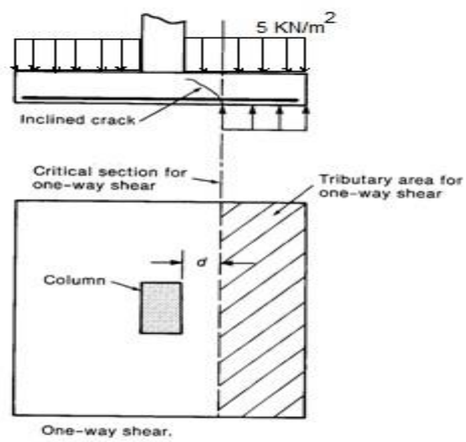


Figure 4. 7: One Way Shear of Footing.

4.10.3.2 Design Footing for two way shear:

$V_u = P_u - FR_b$

$FR_b = q_{u,net} * area\ of\ critical\ section$

$V_u = 4509 - 469.28 * \left((0.75 + 0.613) * (0.9 + 0.613)\right) = 3541.24\ KN$

The punching shear strength is the smallest value of the following equations:-

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

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

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

Where:-

$\beta_C = \frac{Column\ Length\ (a)}{Column\ Width\ (b)}$ ⋙ $\frac{90}{75} = 1.2$

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

$b_o = 2 * (61.3 + 75) + 2 * (61.3 + 90) = 575.2\ cm$

α_s = 40 for interior column

$$\phi.V_C = \phi.\frac{1}{6}\left(1+\frac{2}{\beta_c}\right)\sqrt{f_c'}\,b_o d = 2267.17\ kN$$

$$\phi.V_C = \phi.\frac{1}{12}\left(\frac{\alpha_s}{b_o/d}+2\right)\sqrt{f_c'}\,b_o d = 4602.2\ \text{kN}$$

$$\phi.V_C = \phi.\frac{1}{3}\sqrt{f_c'}\,b_o d = 4318.42\ kN$$

$$\emptyset V_c = 2267.7\ KN > V_u = 817.5\ kN\ \ggg\gg okay$$

4.10.3.3 Design of Bending Moment:

Critical section at the face of column.

$$M_u = 469.28 * \left(\frac{3.1}{2}\right) * \left(\frac{3.1-0.75}{2}\right)^2 = 1004.24\ KN.m$$

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{1004.24 \times 10^6}{0.9 \times 3100 \times 613^2} = 0.95\ MPa$$

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

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times 20.6\times 0.95}{420}}\right) = 0.0023$$

$A_{s,req}$ = ρ.b.d = 0.0023×3100×613 = 43.70 cm^2

$A_{s,min}$ = 0.0018*3100*700 = 39.06 cm^2

$A_{s,req}$ **is control**

Check for Spacing:

S = 3h = 3*70 = 210cm

S = 380*($\frac{280}{\frac{2}{3} * 420}$) – 2.5*75 = 192.5 cm

S = 45 cm **……… is control**

Use 23ø18 in Both Direction

4.10.3.4 Development length of steel reinforcement in footing:

- Tension development length in footing:

$$Ld_{T\ req} = \frac{9}{10} * \frac{F_y}{\lambda\sqrt{f_c}} * \frac{\psi_e \psi_s \psi_t}{\frac{ktr+cb}{db}} * db\ \geq 300\text{mm}$$

$Ktr = 0\ (Nostripes)$

$cb = 75 + \frac{12}{2} = 81\ mm$

$Or\ cb = \frac{150}{2} = 75mm\ is\ control$

$\frac{ktr + cb}{db} = \frac{0 + 75}{12} = 6.25 > 2.5$

$\frac{ktr + cb}{db} = 2.5$

$D = \frac{9}{10} * \frac{420}{1*\sqrt{24}} * \frac{1*1*0.8}{2.5} * 12 = 296.3\ mm < 300\text{mm}$

So, $Ld_{T\ req} = 300\ mm$

$Ld_{T\ available} \frac{1650-500}{2} - 75 = 500\ mm$

$Ld_{T\ available} = 500\ mm > ld_{req} = 300\ mm \ggg\gg \boldsymbol{okay}$

- Compression development length in footing:(For Dowels)

$Ld_{c\ req} = \frac{0.24 * Fy * dB}{\sqrt{f'_c}} \geq 0.043 * \text{f}_y * \text{d}_B \geq 200\text{mm}$

$Ld_{c\ req} = \frac{0.24*420*14}{\sqrt{24}} = 288.05\ mm \geq 0.043 * 420 * 14 = 252.84\text{mm} \geq 200\text{mm}$

$Ld_{c\ req} = 288.05mm$

$Ld_{c\ ava} = 400 - 75 - 12 - 12 = 301mm > Ld_{c\ req} \ggg\gg okay$

- Lap splice of dowels in column:

$L_{sc} = 0.071 * f_y * d_B = 417.48\ mm > 300mm$

Select $L_{sc} = 45\ cm$

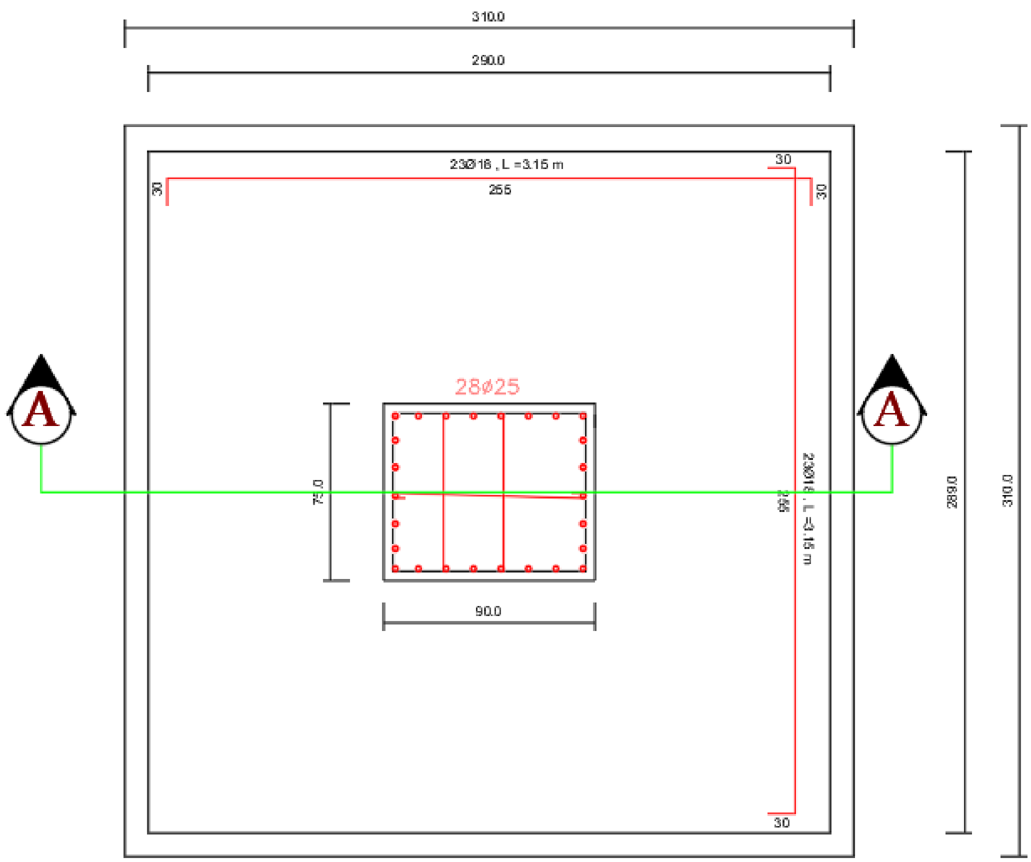


Figure 4. 8: Plan with Reinforcement of the Footing.

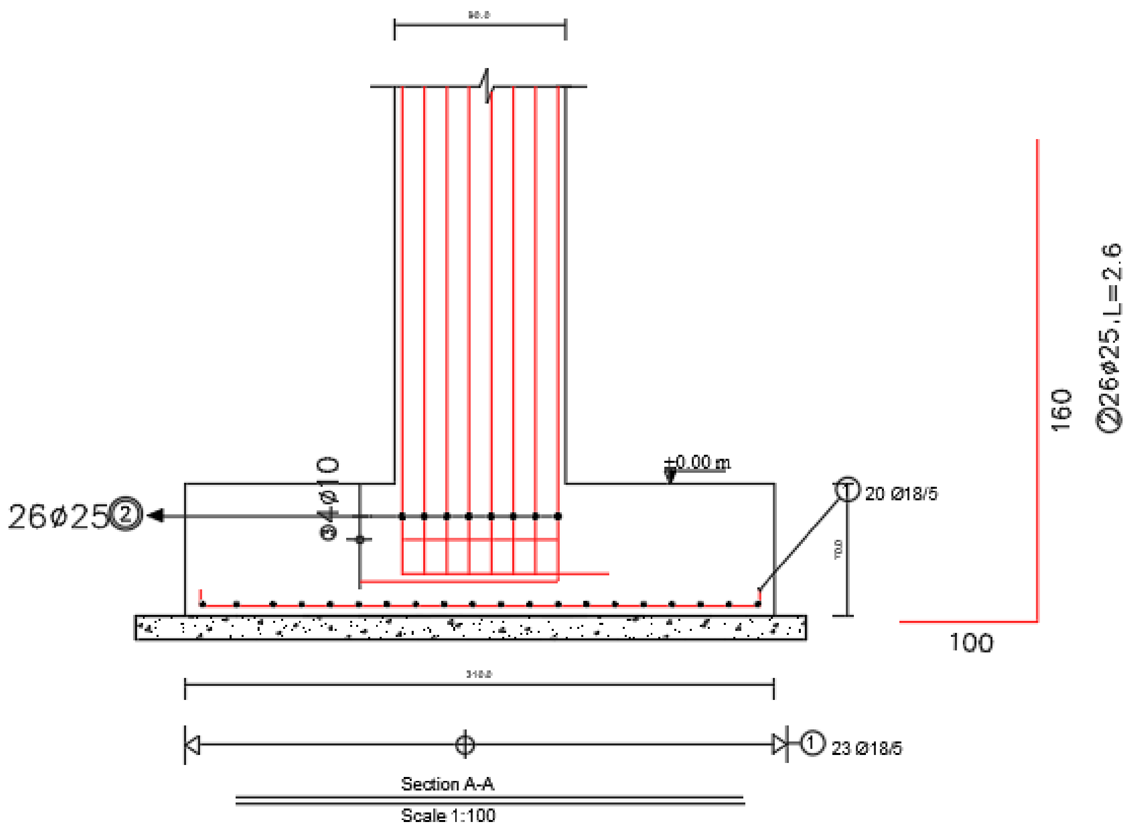


Figure 4. 9: Section in the Footing.

Chapter Five

Results, Recommendations and References

5.1 Results.

5.2 Recommendations.

5.3 References.

5.4 Appendix.

5.1 Results:

1. Each student or structural designer should be able to design manually, so he can get the experience and knowledge in using the computer software.
2. One of the factors that must be taken in consideration is the environment factors surrounding the building, the site terrains, and the forces effects on the site.
3. One of the important steps of the structural design is how to connect the structural members to work together, then to divide these members and design them individually, and should take the surrounding condition in the consideration.
4. Various types of slabs have been used: one-way ribbed slabs, in some slabs that have a regular or nearly regular distribution of columns and beams. One-way solid slabs mainly in the stairs, because it has high resistance to the concentrated forces.
5. The useful software programs were used:
   - AutoCAD 2016, to draw the detail of drawings for structural drawings.
   - ATIR, Etabs, Safe, Sp column, adapt to analysis and design the structural members.

a. Recommendations:

This project has an important role in widening and enhancing the understanding to the nature of the structural project including all the details, analysis, and designs. It is very helpful-through this experience-to introduce a group of recommendations. At the beginning, the architectural drawings have to be prepared and ordered and the construction material and the structural system have to be choose alongside. And it is essential at this stage to have information about the project site, the soil, the soil strength capacity at the site from the geotechnical report, after that the bearing walls and the columns is going to be set up alongside the architectural team in a compatible manner. The civil engineer tries at this stage to plant as much as possible the reinforced concrete walls, which should be use after that in resisting the earthquake loads and other lateral loads.

5.3 References:

1. American concrete institute, Building code requirements for structural concrete ACI 318M, 2011.
2. American concrete institute, Details and Detailing of Concrete Reinforcement ACI315, 1999.
3. Abboushi, Nasr, Reinforced concrete, Palestine polytechnic university, 2013.
4. National Jordanian Construction Council, Jordanian Building Code.

Appendix

TABLE 9.5(a)—MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE CALCULATED

	Minimum thickness, ***h***			
	Simply supported	One end continuous	Both ends continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be damaged by large deflections.			
Solid one-way slabs	**ℓ/20**	**ℓ/24**	**ℓ/28**	**ℓ/10**
Beams or ribbed one-way slabs	**ℓ/16**	**ℓ/18.5**	**ℓ/21**	**ℓ/8**

Notes:
Values given shall be used directly for members with normalweight concrete (density w_c = 2320 kg/m^3) and Grade 420 reinforcement. For other conditions, the values shall be modified as follows:
a) For structural lightweight concrete having unit density, w_c, in the range 1440-1920 kg/m^3, the values shall be multiplied by $(1.65 - 0.003w_c)$ but not less than 1.09.
b) For f_y other than 420 MPa, the values shall be multiplied by $(0.4 + f_y/700)$.

[1] MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE CALCULATED. -ACI Code-

الجدول (٣-١-ب)

تابع الأحمال الحية للأرضيات والعقدات

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الاشغال	كن/م٢	كن
تابع مباني التجمعات العامة.	تابع القاعات، قاعات الاجتماعات، المطاعم، المتاحف، المكتبات،	الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.	4.0	4.5
	النوادي، المسارح،	المنصات.	7.5	4.5
	ستوديوهات الاذاعة.	أرضيات المتاحف وصالات عرض الفنون.	4.0	4.5
		أماكن العبادة (المساجد والكنائس).	3.0	2.7
مباني المكاتب.	المكاتب والبنوك.	مستودعات القرطاسية.	4 لكل متر من ارتفاع التخزين.	9.0
		غرف حفظ الملفات.	5.0	4.5
		قاعات البنوك.	3.0	–
		مكاتب للاستعمالات الخفيفة.	2.5	2.7
		الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.	4.0	4.5

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[2] LIVE LOAD