Palestine Polytechnic University

College of Engineering

Structural design of a multi-floors villa with a floor area equal 750 m^2.

" Dr. Nabil's Villa "

By:

Sabiha Amirah

Supervisor: Dr. Maher Amro

Submitted to the College of Engineering

In partial fulfillment of the requirements for the

Bachelor degree in Civil Engineering

Palestine Polytechnic University

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The undersigned here by certify that they have read, examined and recommended to the Department of Civil Engineering and Architecture in the College of Engineering and Technology at Palestine Polytechnic University the approval of a project entitled: Structural Design of a multi-floors villa with a floor area equal 750 m2. "Dr. Nabil's Villa "submitted by Sabiha Amirah for partial fulfillment of the requirements for the bachelor's degree circle.

Dr. Maher Amro. (Supervisor), Palestine Polytechnic University.

Signature: Date:

Project Approved

Dr. Belal Almassri Department of Civil Engineering Palestine Polytechnic University

Signature: Date:

DEDICATION

To those who have always believed in me and given me wings to fly and told me that there are no limits in the sky.

To those who have helped me throughout my learning years without every grumbling about my curiosity and appetite to knowledge.

To those who have always showered me with unwavering support and care.

To those who know themselves and know what they mean to me without the need of articulation. Those are my family, friends and teachers and for them I dedicate this research, hoping that -by doing so- I am repaying them a little amount of what they owe me

Acknowledgement

Thanks be to Allah for this guidance and providence!

I would like to take the opportunity to wholeheartedly thank to everyone who supported to me

I especially thank:

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

• All lecturers at the university.

I would especially like to thank **Dr. Maher Amro**, who extended Great effort on the project.

I thank the two engineers, **Elham and Haya Nasser El Din**, for the architectural project

• The university library with its entire staff to provide us with the necessary books and resources.

• Everyone who helped in the project and got great help

Abstract

Structural design of a multi-floors villa with a floor area equal 750 m^2.

Supervision: D. Maher Amro

Sabiha Amirah

Structural design is the most important design of the building after the necessary architectural design, distribution of columns, loads, durability of display, best prices and the highest levels of safety are the responsibility of the structural designer.

In this project I will do structural design for "multi-floors villa"

The villa consists of three floors; The ground floor has a living room, kitchen, guest sitting room with bathroom, guest bedroom with bathroom, master room and gym room (entertainment room). The first contains two master rooms, two bedrooms, a bathroom, kitchen and living room. The last floor (roof) contains a living room, kitchen, master bedroom, and bathroom

Total area 750 m2.

This project was chosen due to the importance of knowing how to design these buildings.

It is worth noting that I will use the Jordanian code to determine live loads, and to determine seismic loads, for structural and structural analysis.

Design departments I will use US code (ACI_318_14), and it should be noted that I will rely on some computer software such as: AutoCAD, Office, Attir.

After the completion of the project I expect to be able to provide the structural design for all structural elements of the project in accordance with the requirements of the code.

الملخص :

التصميم الإنشائي هو أهم تصميم للمبنى بعد التصميم المعماري اللازم وتوزيع الأعمدة والأحمال ومتانة العرض وأفضل الأسعار وأعلى مستويات الأمان تقع على عاتق المصمم الإنشائي.

"في هذا المشروع سأقوم بالتصميم الإنشائي لـ "فيلا متعددة الطوابق "

تتكون الفيلا من ثلاثة طوابق. الطابق الأرضي يحتوي على غرفة معيشة ومطبخ وغرفة جلوس للضيوف مع حمام وغرفة نوم للضيوف بحمام وغرفة رئيسية وغرفة جيم (غرفة ترفيه). الأول يحتوي على غرفتين رئيسيتين وغرفتين نوم وحمام ومطبخ وغرفة معيشة. الطابق الأخير (الروف) يحتوي على غرفة معيشة ومطبخ وغرفة نوم رئيسية وحمام

المساحة الإجمالية 750 متر مربع .

تم اختيار هذا المشروع لأهمية معرفة كيفية تصميم هذه المباني .

ومن الجدير بالذكر أننا سوف نستخدم الكود الأردني لتحديد الأحمال الحية ، وتحديد الأحمال الزلزالية ، للتحليل الإنشائي

(ACI_318_14) أقسام التصميم سوف نستخدم كود الولايات المتحدة

وتجدر الإشارة إلى أننا سنعتمد على بعض برامج الكمبيوتر مثل

AutoCAD ،Office ،Attir.

بعد الانتهاء من المشروع أتوقع أن أكون قادرين على تقديم التصميم الإنشائي لجميع العناصر الهيكلية للمشروع بما يتوافق مع متطلبات الكود.

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List of Abbreviation

- **b** = width of compression face of member

. • **bw** = web width, or diameter of circular section

. • **DL** = dead load.

- **d** = distance from extreme compression fiber to cancroids of tension reinforcement.

- **Ec** = modulus of elasticity of concrete.

- **Fy** = specified yield strength of non-prestressed reinforcement.

- **Ln** = length of clear span in long direction of tow-way construction, measured face-to face of supports in slabs without beams and face to face of beam or other supports in other cases

. • **LL** = live load.

. • **M** = bending moment.

- **Mu** = factored moment at section.

- **Mn** = nominal moment.

- **Pn** = nominal axial load.

- **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.
- **Vu** = factored shear force at section.
- **h** min= Minimum thickness of slab
- **εc** = compression strain of concrete = 0.003mm/mm.
- **ρ** = ratio of steel area.
- **KN**= Kilo Newton

Chapter 1

Introduction

1-1 Background

Availability of a safe home that secures human life, protects him from dangers, and provides him with all means of security and stability is an urgent necessity and a goal that man has striven to achieve and has harnessed for this purpose many studies and tests until he reaches the material that achieves what he wants from security and stability. This material was the cement that provided A person has to spend a lot of time and effort to get a safe home.

This project is based on a review of a model of human creativity in construction, in which the architectural plans of a three-floor residential villa will be addressed. In this project, these architectural plans will be worked on and dealt with in terms of construction and implementation and the application of all structural safety requirements and accordingly, the full executive construction plans will be prepared for the project to be ready for implementation.

1-2 Aims and objectives

Fulfilling part of the requirements for obtaining a bachelor's degree in engineering, specializing in buildings.

I hope that after completion of this research I have come to the following

objectives:

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

2) The ability to design the various structural elements.

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

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

1-3 problem statement

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

1-4 literature review

In construction projects similar to this project, has been used slab one way and two-way rib slab, but in this project, use been a one-way rib slab.

and in that project use been hidden beams but in other projects, also dropped beams were used

1-5 Methodology of the project

1. Architecture design (construction drawings, elevations, sections, public location).
2. Study the units structurally to identify structural elements, loads on the buildings, and the selection of appropriate structural system.
3. Distribute columns to the chosen structural system.
4. Structural analysis of all structural elements of the units.
5. Structural design of all structural elements.
6. Preparation of construction drawings of the building to remove the executable image.
7. Writing project in accordance with the requirements of the construction engineering

1-6 The scope of the Project

Project contains several chapters are detailed as follows:

- **Chapter One**: A general introduction to the project.
- **Chapter Two**: Includes description of architectural project.
- **Chapter Three**: Contains a description of the structural elements of the project

. **Chapter Four**: Analysis and structural design of all structural elements.

- **Chapter Five**: The results that have been reached and recommendations

1-7 Time plan

Figure (1.1): The Stages of The Project.

Table (1.1): Time Table

Task \ Week No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Select project	■	■	■	■	■																											
Inception report					■	■	■																									
Collect information							■	■																								
Architectural study									■	■	■																					
Structural study											■	■	■																			
Prepare the introduction														■	■																	
Display the introduction																■																
Structural analysis																	■	■	■	■	■											
Structural design																				■	■	■	■	■	■							
Prepare the project plans																										■	■	■				
Write the project																													■	■	■	
Project presentation																																■

Chapter Two

Architectural Description

2.1 INTRODUCTION.

2.2 THE MAIN ELEMENTS IN the multi-floor villa

2.2.1 INTERIOR SPACES.

2.2.2 EXTERNAL SPACES

2.3 PROJECT PLANS.

2.4 PROJECT ELEVATIONS.

2.5 PROJECT SECTIONS

2.1 Introduction

Architectural description is the most important things that should be consider when preparing for any project because of its importance in defining and understanding the nature of the project and its sections. Architectural design requirements task must meet the desired job and human needs in the present time, these terms are in the functional, lasting beauty and economy, it is important in these conditions can interact between each other and in harmony to achieve our vision of optimal design and get an integrated and comprehensive architectural design, and this is achieved by understanding the functional demands of the building and space as well as taking into account nature movement of each part of the project.
Architectural study that must precede the start of architectural design must be easy to handle and understand different events that it contains building and functional relations among them, and the nature of the association movement and using these parts, and other things of importance that give a clear picture of the project and therefore it will be possible to locate the columns and other structural elements to suit architectural design.

2.2 THE MAIN ELEMENTS IN the multi-floor villa

The project areas are divided into internal and external spaces tied together to achieve the goals that were found for it.

2.2.1 Interior spaces are divided into:

 Ground floor:

 This floor has an area of 292.26 m²

Living room & kitchen: 49.13 m²

Master bedroom, bathroom: 29.89 m²,7.50 m²

Guests bedroom, Bath: 21.22 m²,4.88 m²

Guests Room & dining room, bath: 43.50 m²

Entertainment room, bath: 33.75 m² ,2.41m²

First floor:

The area of this floor is 190.24 m²

Living room & kitchen:46.62m²

Bedroom1:15.56 m²

Bedroom2:13.26 m²

Bathroom:3,34 m²

Laundry:1.82m²

Master bedroom, bath: 20.56,4.22 m²

Master bedroom:20.56 m²

Roof floor:

The total area of this floor:90.85 m²

Living room& kitchen: 35.41 m²

Master bedroom & Bathroom: 30.75m²

Bathroom:5.85 m²

2.2.2 External Spaces Consist

of:

- Green spaces.

Outdoor seating

Balcony

2.3 Project Plans

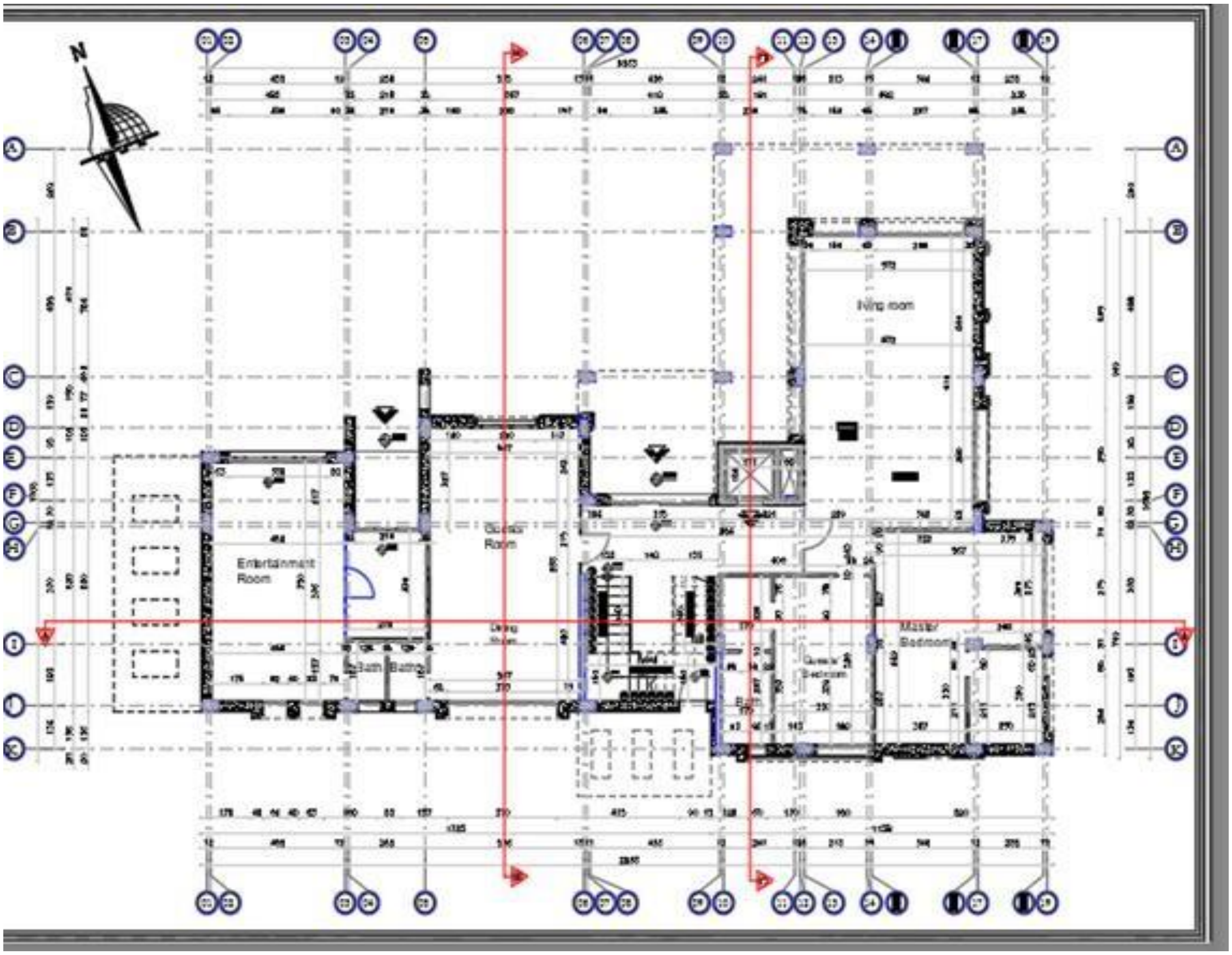


Figure 2.1 Dimension plan

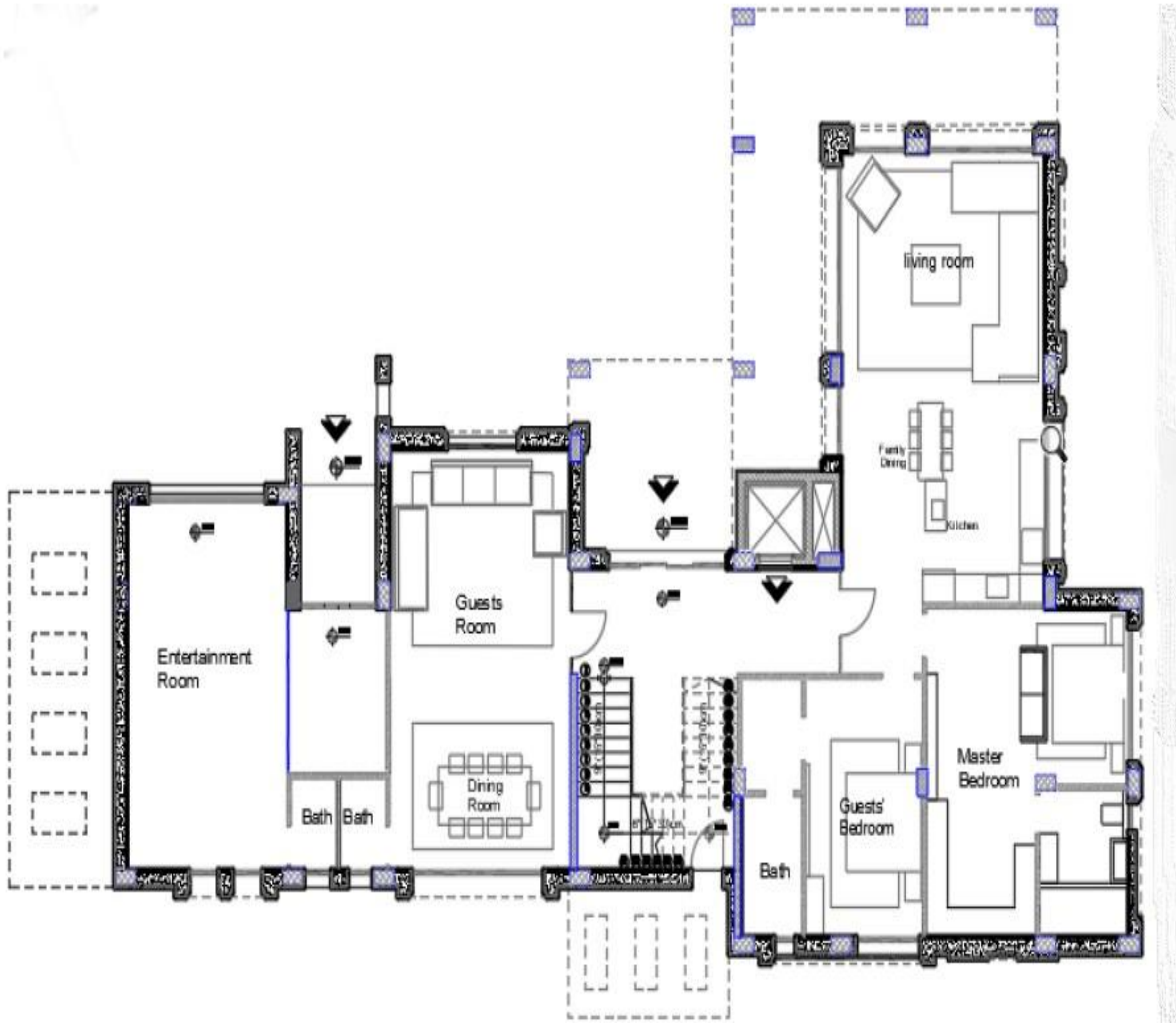


Figure 2.2 Plan ground floor

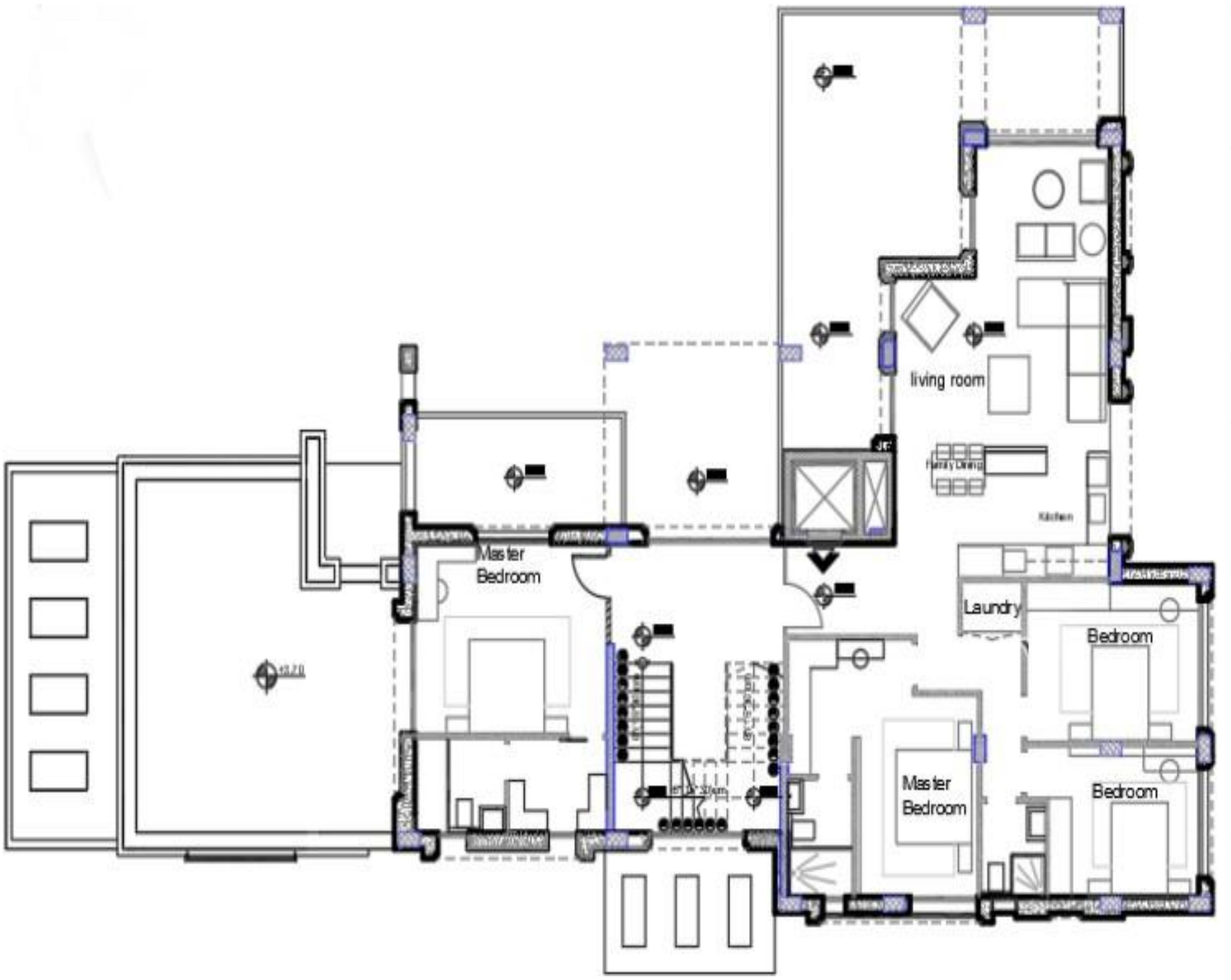


Figure 2.3 Plan first floor

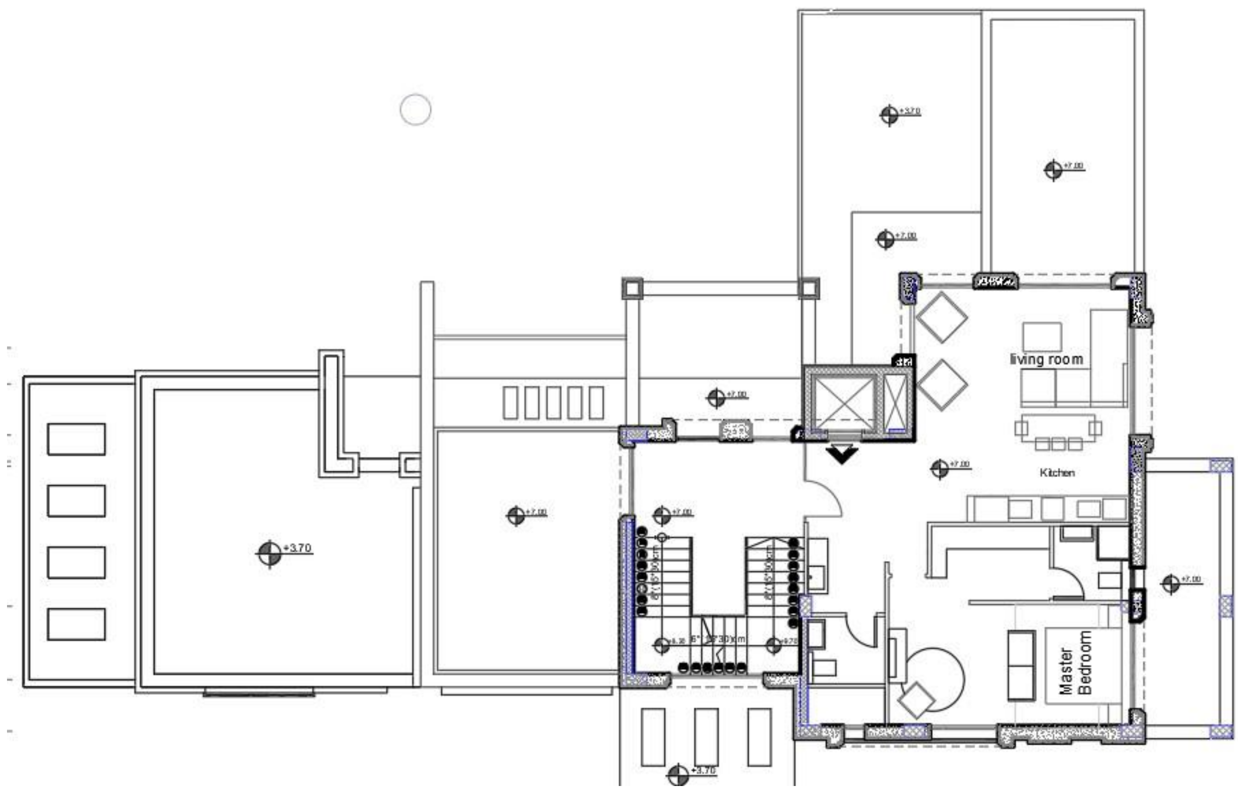


Figure 2.4 Plan roof floor

2.4 Project Elevations

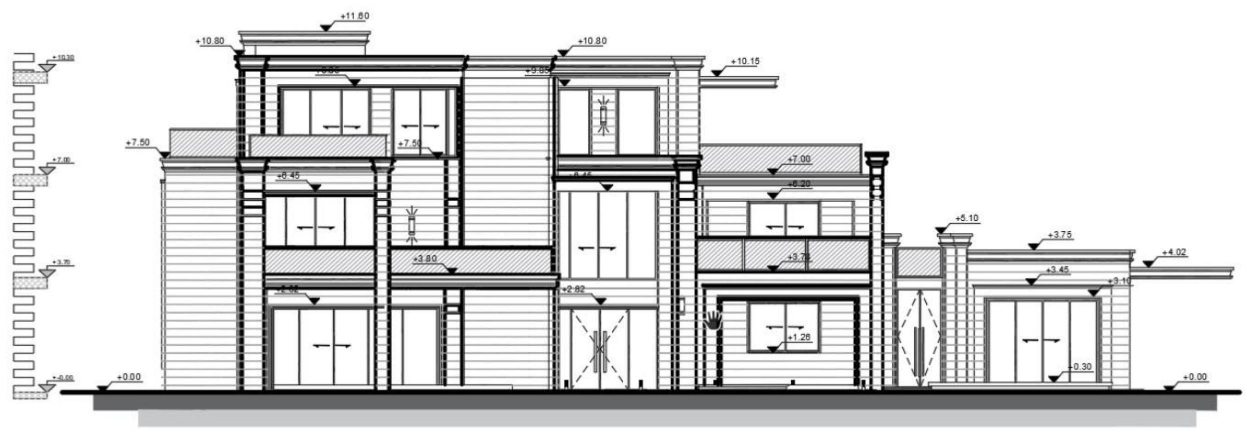


Figure 2.5 North elevation

Figure 2.6 South elevation

Figure 2.7 east elevation

Figure 2.8 West elevation

2.5 Project Sections

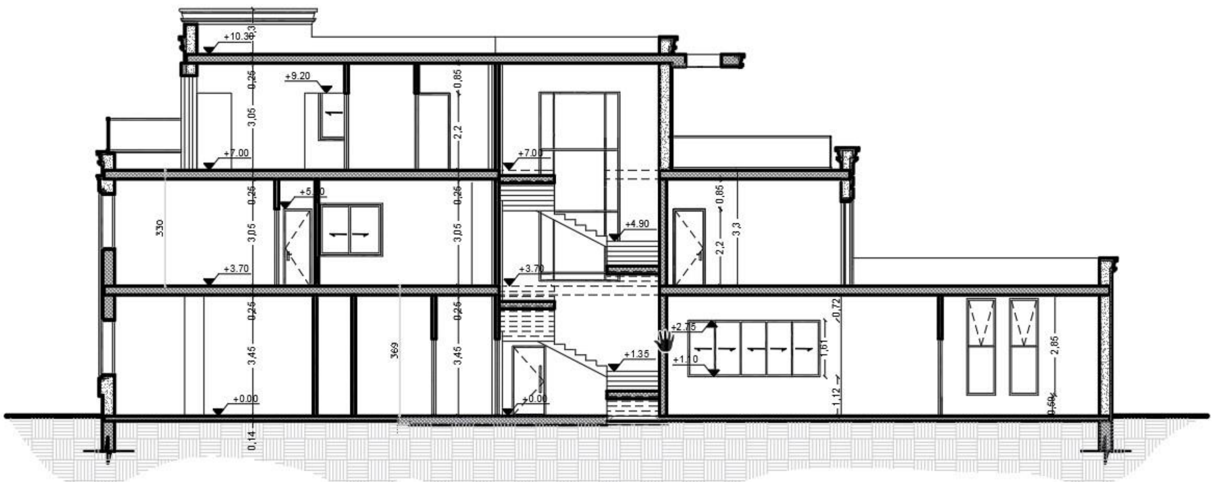


Figure 2.9 A-A section

Section B-B

Figure 2.10

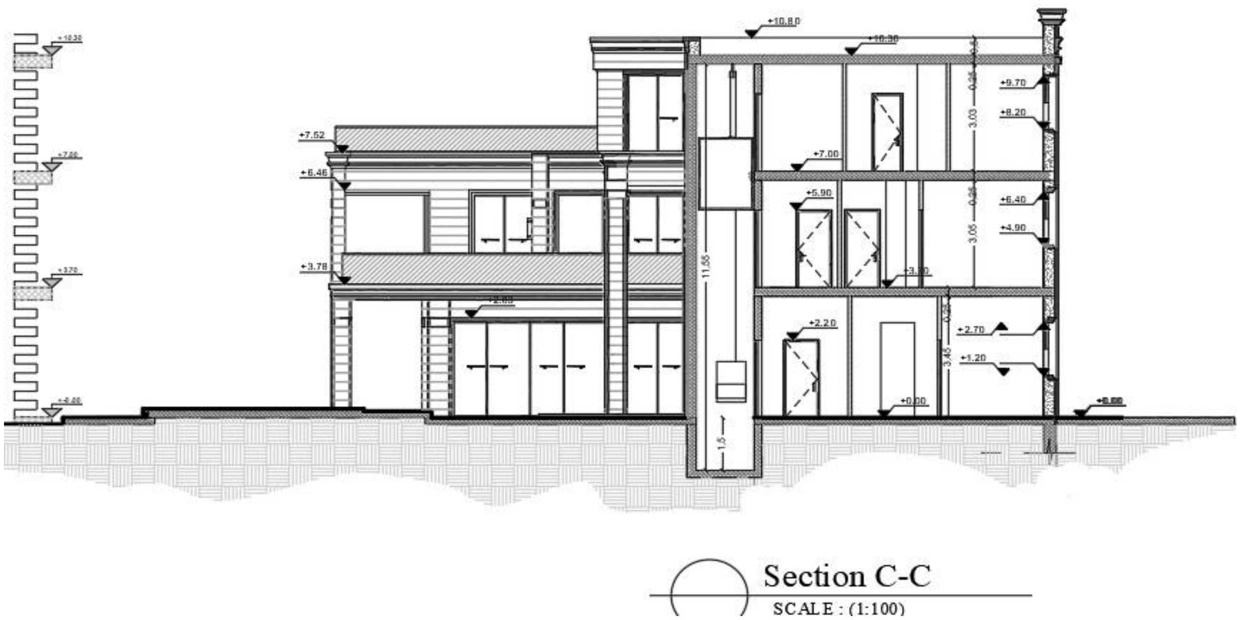


Figure 2.11

Chapter Three

Structural Description

3.1 INTRODUCTION.

3.2 THE GOAL OF THE STRUCTURAL DESIGN.

3.3 SCIENTIFIC TESTS.

3.4 STAGES OF STRUCTURAL DESIGN.

3.5 LOADS ACTING ON THE BUILDING.

3.5.1 DEAD LOADS

3.1 Introduction

The main objective of the process design is to ensure the existence of necessary operating advantages with structural elements on the most suitable dimensions in terms of security and economic terms.

The knowledge of structural elements of any project is essential in the design of reinforced concrete structures to make comparisons between different types of these elements for the construction of safer system. So the structural elements that go into the design of this project will be described.

3.2 The aim of the Structural Design:

The structural design is an integrated and balanced structural system capable of carrying it meet the established requirements and desires of users, and thus determines the structural elements from the following:

1- Factor of Safety: Is achieved by selecting sections for structural elements capable of withstanding the forces and resulting stresses.

2- Economy: Check by choosing the appropriate building materials and by choosing the perfect low-cost section.

3- Serviceability: To avoid excessive landing (deflection), fissures (cracks).

4- Preservation of architectural design.

5- Preserving the environment.

3.3 Scientific Tests:

Before the design of any construction project must be doing some tests, tests of the soil to see breaking strength, specifications, type, the underground water level and depth of the foundation layer, and through holes up and depths measured.

3.4 Stages for Structural Design:

We will distribute the structural design of the project in two phases: -

1. The first stage: - In this stage, the appropriate structural system of project construction and analysis for this system will be determined.

2. The second stage: - The structural design of each element of the set is detailed and accurate according to the chosen construction system and structural blueprints for executable

3.5 Loads Acting on the Building:

Is a group of forces that are designed to endure, and that any building is subjected to several types of loads must be calculated and selected carefully because any error in identifying and calculating loads reflects negatively on the structural design of various structural elements. The building is exposed to loads of live and dead loads, wind loads, snow loads, loads of earthquakes.

The permanent forces and resulting from strong gravity which are fixed in terms of amount and location and does not change during the age of the building, and the loads on the weight of structural elements and the weights of the items based upon sustainably as cutters and walls, as well as the weight of the body adjacent to the building permanently, and the calculation and estimate the loads by knowing the dimensions of the structural elements and specific gravity of the material used in the manufacture of structural elements, And are most often include: concrete, and Rebar, and plaster, and bricks, tiles and finishes, and the stone used in building coverage abroad, there is also a tube extension, as well as suspended ceilings and decorations for the building.

3.5.1 Dead Loads

Table (3-1) Dead load

Material	Density(KN/m^3)	Thickness(m)
Tiles	22	**0.03**
Mortar	22	**0.02**
Sand	16	**0.07**
Concrete	25	**0.08**
Plaster	22	**0.02**
Partition=1.5 KN/m^2		

3.5.2 Live Loads

Which are the loads that are subjected to buildings and constructions depending on various uses, including distributed and concentrated loads, which include the following:

1. The weights of the villa users.
2. Dynamic loads, such as devices that produce vibration.
3. Static loads, which can be changed from time to time, such as furniture, machines, static unstable machines, stored materials, furniture, equipment.

Table (3-2) Determination of live load

NO.	Type of Area	Live Loads (KN/m^2)
1	المباني السكنية	2

3.5.3 Snow Loads

Figure (3.1): snow loads.

Snow loads can be calculated by knowing the altitude using the table below by Jordanian code.

حمل الثلج (S_o) (كن/م٢)	ارتفاع المنشأ عن سطح البحر (h) (بالمتر)
0	250 > h
(h-250)/800	500 > h > 250
(h-400)/320	1500 > h > 500

Figure (3.2): Determination of snow load, Jordanian loads code

Based on the scale of previous snow loads and after selecting the high building surface and that equals (1030m) according to item III snow load is calculated as follows:

SL= (h-400)/320

SL= (1030-400)/320= 1.97 KN/m².

3.5.4 Earthquake Load:

Produce earthquakes of horizontal and vertical vibrations due to the relative motion of the Earth rock layers, resulting in strong cut affect the origin, and these loads must be taken into account in the design to ensure resistance to earthquakes. This will be resisted by shear walls designed with sufficient thickness and reinforcement to ensure the safety of the building when subjected to earthquakes loads that must be considered in the design process to reduce the risk and maintain the performance of the building, and determine the loads of earthquakes and shear forces depending on the American code (UBC).

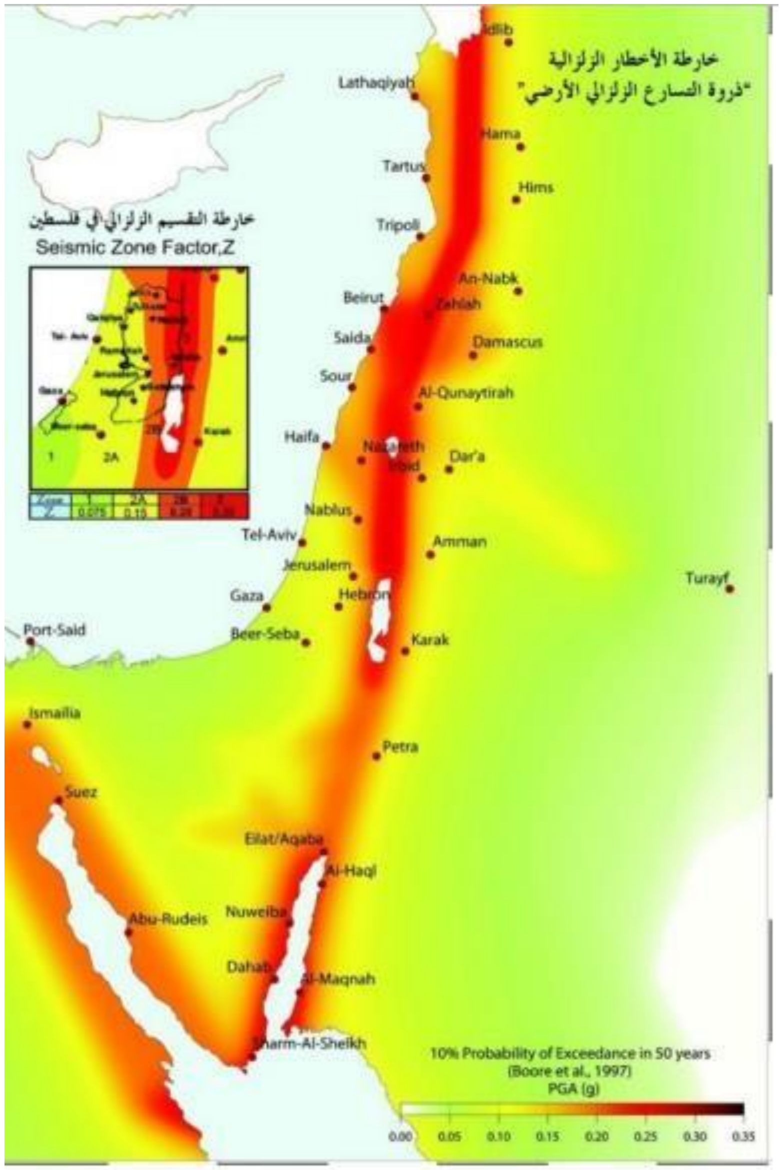


Figure (3.3): Earthquake map for palestine

3.5.5Wind Loads:

Wind loads affect the horizontal forces on the building, and the wind load determination process is depending on wind speed and change height from the surface of the Earth and the location of where his high buildings or having established himself in the high or low position and many other variables.

Figure (3.4): Wind Pressure on buildings.

3.6 Structural Elements of the Building:

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

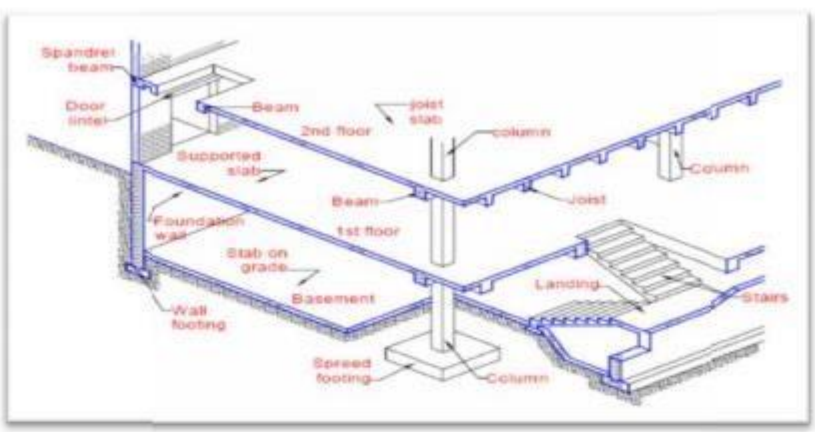


Figure (3.5): Structural Elements of the Building.

3.6.1 Slabs

Structural elements are capable of delivering vertical forces due to the loads affecting the building's load-bearing structural elements such as beams, columns, and walls, In this project, two types of components both in its appropriate place, and which will clarify the structural design in the subsequent chapter, and below two types:

One-Way Ribbed Slab.

One-way solid slab

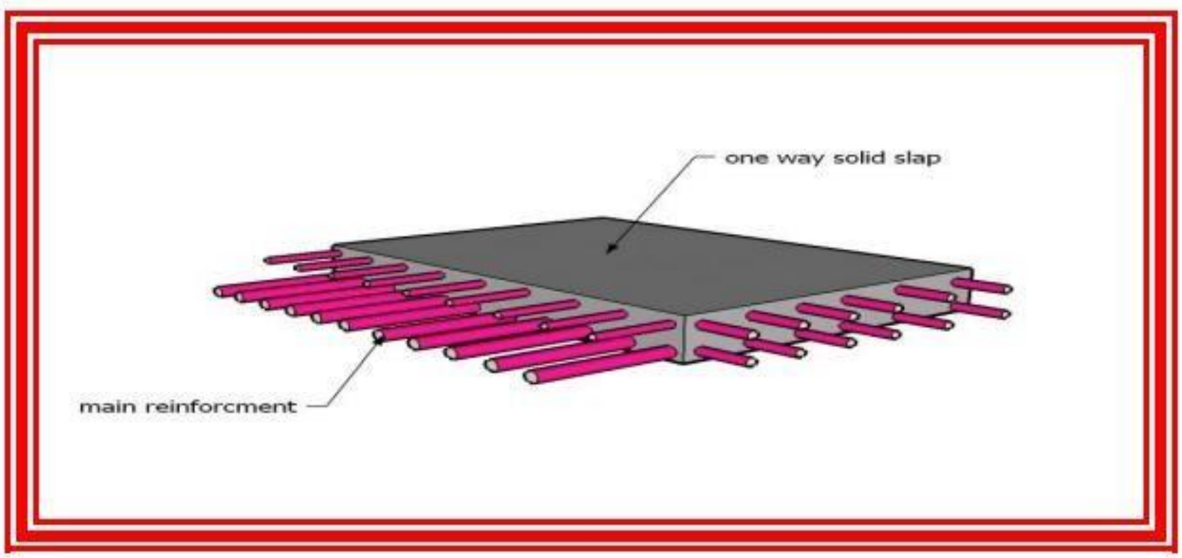


Figure (3.6) Solid Slab.

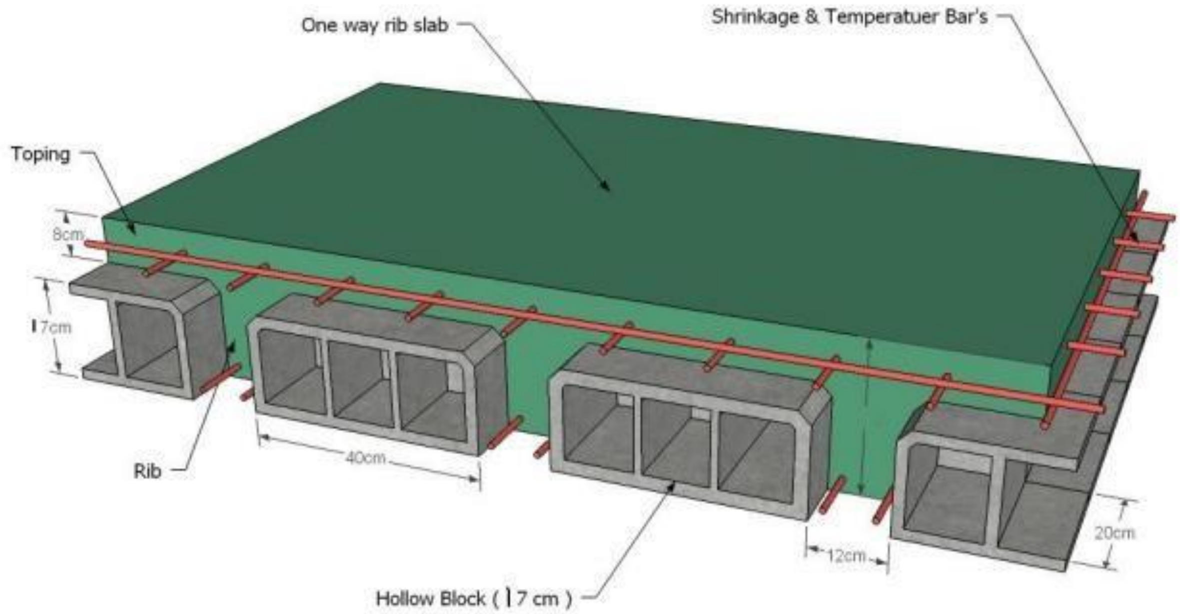


Figure (3.7) One Way Ribbed Slab

3.6.2 Stairs

The architectural elements used for vertical transmission between the different levels of the lever through the building, and will be one of inclusion type design development.

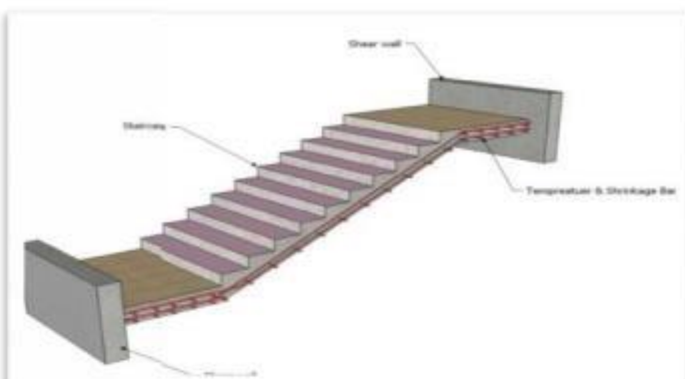


Figure (3.8) The shape of stairs.

3.6.3 Beams

The basic structural elements in moving load of tiles into columns, and are of two types:

1-Hidden Beam: Hidden inside Slabs.

2- Dropped Beam: (Paneled Beam).

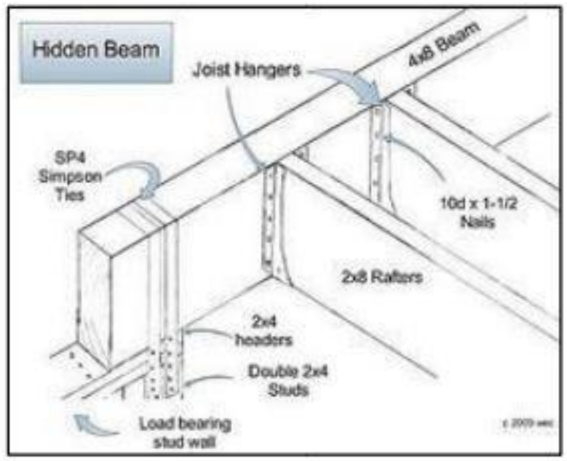


Figure (3.9) Hidden Beam.

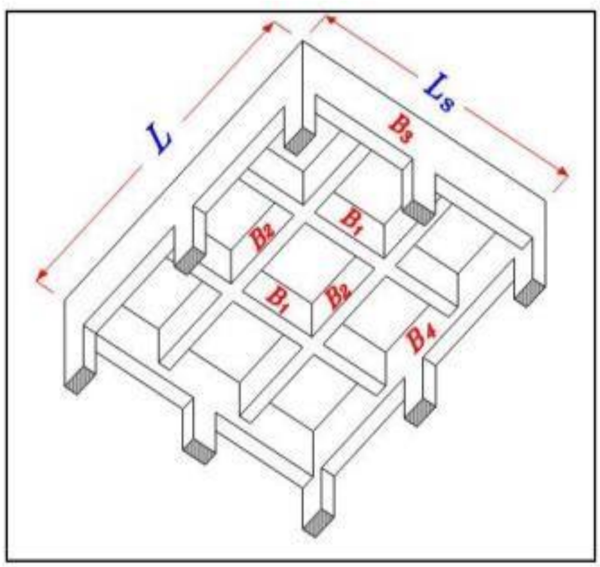


Figure (3.10) Paneled Beam.

This project includes only hidden beams

3.6.4 Column

The column is an important element in moving loads of bridges to the foundations, it is essential to transfer the loads and the building, and therefore must be designed so as to be able to download and load them, and two rectangular and square concrete columns.

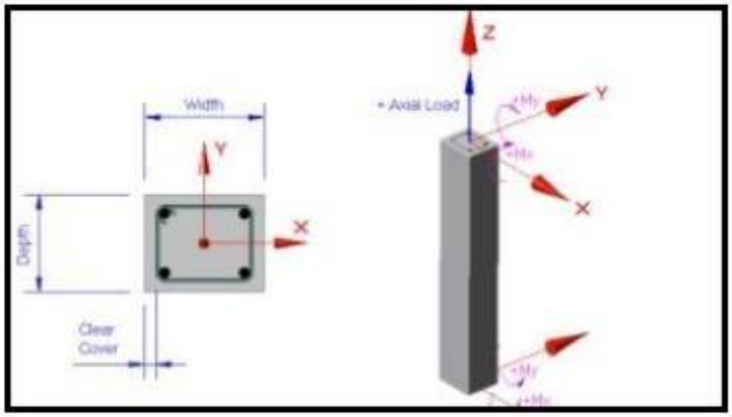


Figure (3.11) Column.

3.6.5 Shear wall Is a structural system composed of braced panels (also known as shear panels) to counter the effects of lateral load acting on the building, the building contains a number of shear wall continued from Foundation to the end minaret.

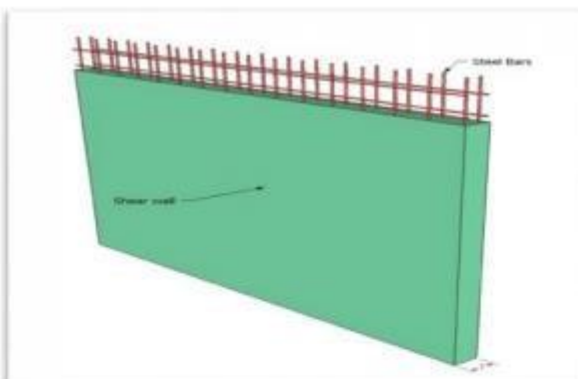


Figure (3.12) Shear Wall.

3.6.6 Foundation

Although the foundations are the first element constructs, but we did the design after the completion design all the structural elements in the building. The foundations are the link between the structural elements in the building and the earth. The loads on the slab move to the beams and then to the columns and finally to the foundations to the soil. The foundation is responsible for carrying the dead loads of the building and also the dynamic loads resulting from wind, snow and earthquakes. Also Live loads inside the building. We determined the type of foundations depending on the strength of the soil and the loads on each footing.

3.6.6.1 Shallow Foundation

The foundation is close to the surface of the earth, and this type has several forms, such as strip (wall) footings, isolated footing or mat footings.

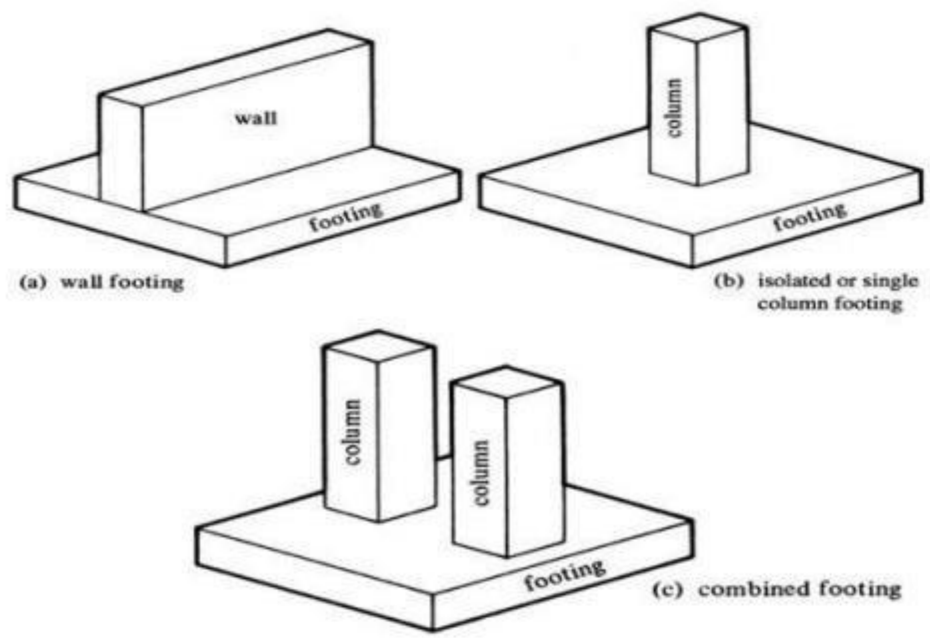


Figure (3.13): Shallow Foundation

3.7 Structural programs

1. AutoCAD (2007/2014) for Structural and Architectural Drawings.

2. Microsoft Office word (2010) For Text Edition.

3. Atir 11.5 (BEAMD).

4. Safe

5. Etabs

CHAPTER 4

4.1: Introduction

Concrete is a construction material composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate such as gravel, limestone, or granite, plus a fine aggregate such as sand), water, and chemical admixtures. The word concrete comes from the Latin word "concretus", which means "hardened" or "hard".

Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material. Concrete is used to make pavements, architectural structures, foundations, motorways/roads, bridges/overpasses, parking structures, brick/block walls and footings for gates.

.

In This Project, there are two types of slabs: solid slabs and one-way ribbed slabs. 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, and then hand calculation would be made to find the required steel for some members.

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-code.

4 .2: Factored Loads.

The factored loads on which the structural analysis and design is based for our project members, is determined as follows:

qu = 1.2DL + 1.6L ACI – 318 - 08 (9.2.1)

4.3: Determination of Thickness:

Determination of Thickness for One Way Rib Slab:

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 overall depth must satisfy ACI Table (9.5.a):

Spans from left to right for one-way slab:

$\frac{l}{18.5} = \frac{455}{18.5} = 24.5$ cm

$\frac{l}{21} = \frac{459}{21} = 21.8$ cm

Select Slab thickness h= 25cm with block 17 cm & Topping 8cm.

4.4: Load Calculation:

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 follows:

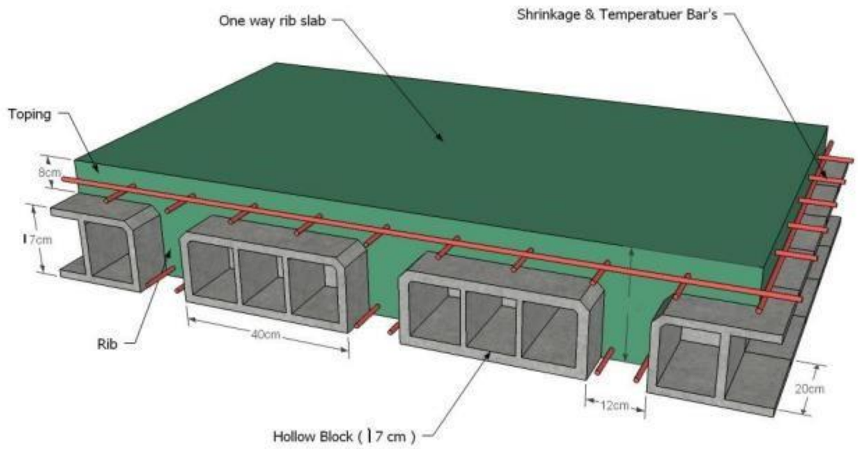


Fig. (4-1) One-way rib slab

Calculation of the total dead load for one-way rib slab is shown in the following table:

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

No.	Parts of Rib	Calculation	
1	Rib	0.12*0.2*25 = 0.6 KN/m	
2	Top Slab	0.08*0.52*25 = 1.04 KN/m	
3	Plaster	0.03*0.52*22 = 0.343 KN/m	
4	Block	0.2*0.4*10 = 0.8 KN/m	
5	Sand Fill	0.07*0. 52*17 = 0.5824 KN/m	
6	Tile	0.03*0. 52*23 = 0.619 KN/m	
7	Mortar	0.03*0. 52*22 = 0.343 KN/m	
8	partition	1.25*0.52 = 0.65 KN/m	
		4.8	KN/m of rib

Nominal Total Dead Load:

D.L. total = 4. 8 KN/m of rib

Live load = 2 * 0.52 = 1.04 KN/m of rib

4.5: Design of Topping:

Design of Topping for Ribbed Slab:

Table (4.2) Calculation of the total dead load for topping.

No.	Parts	Density	Calculation
1	Tiles	23	23×0.03=0.69 KN/m
2	Mortar	22	22×0.03=0.66 KN/m
3	Coarse Sand	17	17×0.07=1.19 KN/m
4	Topping	25	25×0.08=2 KN/m
5	Partition		1.25 1=1.25 KN/m

Dead load of topping =

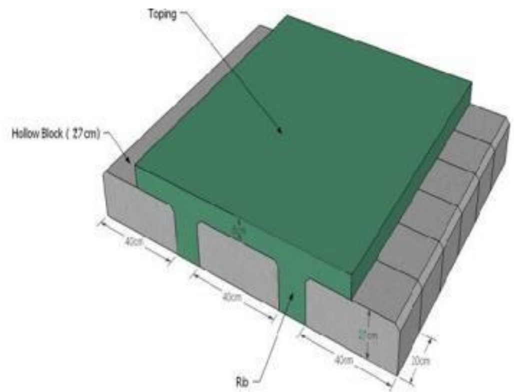
5.79 KN/m

Live Load = 2 KN/m²

Wu = (1.2 * 5.79) + (1.6 * 2)

=10.15 KN/m

Figure (4.2): Toping of slab



Design of Topping for Ribbed Slab as a Plain Concrete Section: -

For a one-meter strip wu = 10.15 KN/m

$Mu = \frac{Wu*l^2}{12} = \frac{10.15*.4^2}{12}$ = .135 KN.m

$Vu = \frac{Wu*l}{2} = \frac{10.15*.4}{2} = 2.03\ kN$.m

Design of moment

$Mn = .42 * \sqrt{24} * \frac{1000*80^2}{6} * 10^{-6}$ = = 2.198 KN.m

 Mn = 1.209 KN.m > Mu = 0.135 KN.m

No structural reinforcement is needed. Therefore, shrinkage and temperature reinforcement must be provided. For the shrinkage and temperature reinforcement:

ρ =0.0018 ACI-318-08 (7.12.2)

As = ρ * b * h = 0.0018 * 100 * 8 = 144 mm².

Useø8 @ 25 cm.

4.6 Design of Rib:

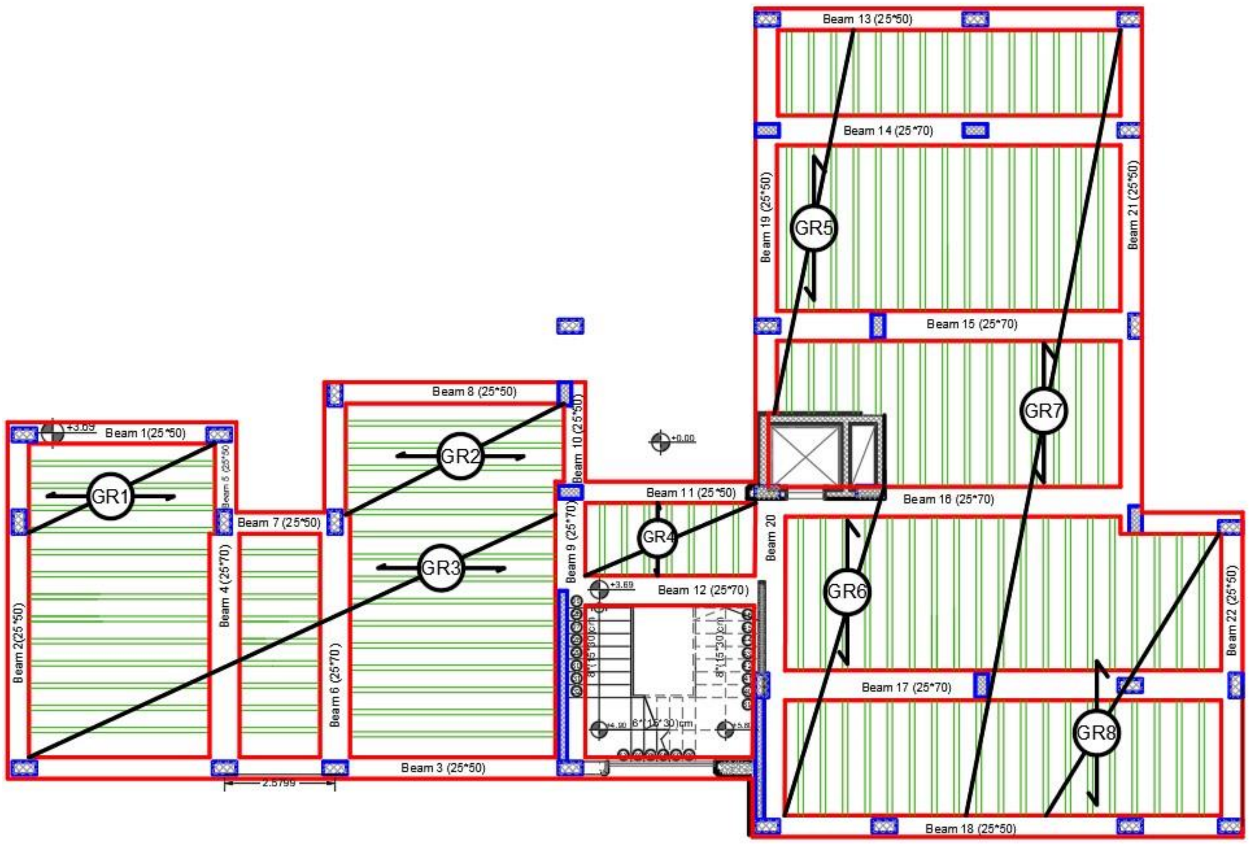


Figure (4.3) Rib location

By using ATIR program we get the envelope moment and shear diagram as the follows:

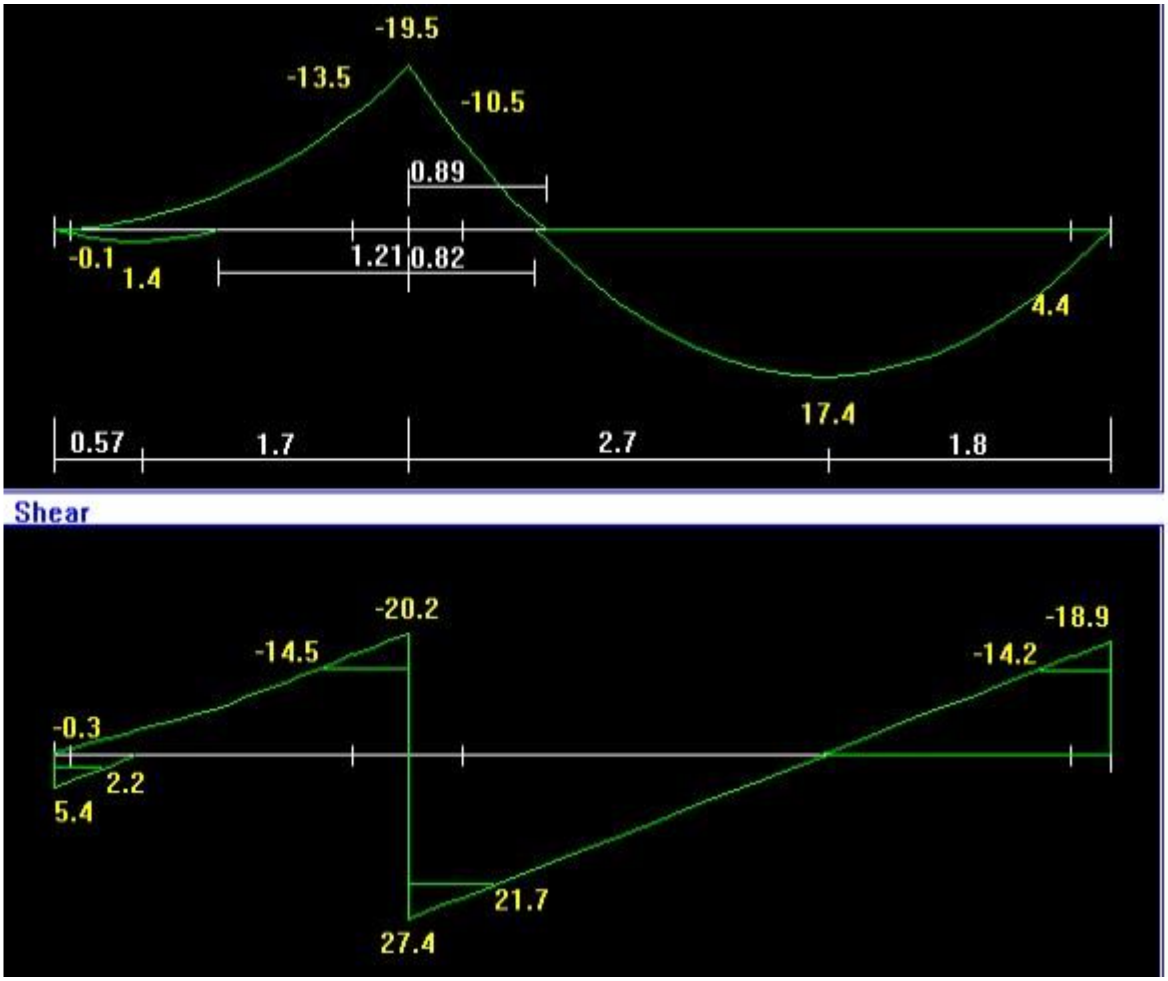


Figure (4.4) Moment and shear

4.6.1: Design of Positive Moment for Rib:

Effective Flange width (bE) , ACI-318-11

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

be = (2.06) / 4 =52 cm be =

120 + 16 (80) = 140cm

be = 52 cm.................. control

Use Mu max positive for span 2 :17.4= KN.m

Determine whether the rib will act as rectangular or T – section:

For hf = 0.08 m

Assume bar diameter main positive reinforcement.

d = 250 – 20 – 10–7= 213 mm

□*Mn= 146.81 KN.m>> Mu = 17. 4KN.m

The section will be designed as a rectangular section with be = 520mm

$$Asmin = \frac{\sqrt{fc'}}{4fy}(bw)(d) \geq \frac{1.4}{fy}(bw)d$$

$$Asmin = \frac{\sqrt{24}}{4*420}(120)(213) \geq \frac{1.4}{420}(120)213$$

$$\frac{\sqrt{24}}{4*420}(120)(213) = 74.53mm^2$$

$\frac{1.4}{420}(120)213 = 85.2mm^2$-control

$$m = \frac{fy}{.85fc'} = \frac{420}{.85*24} = 20.6$$

$Rn = \frac{Mu}{\emptyset bd^2} = \frac{17.2}{.9*520*213^2} =$ .810 MPa

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*m*Rn}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*.810}{420}}\right)$ =.0019

A s = 0.0019(520) (213) = 210.444mm²> A s min = 85.2 mm²

A s = 210.44 mm² control

# of bars = As / As bar = 210.44/153.94

= 2 φ 12

226.19 mm²> 85.2 mm².

* Check Strain for the magnitude of under strength factor Φ:

$a = \frac{(fy*As)}{.85*24*520} = a = \frac{(420*226.19)}{.85*24*520}$ = 12.19 mm

$c = a/.85$ = 14.34mm s = $.003(d -$

$c)/c$ = .041>.005 – ok

4.6.2: Design of Negative Moment for Rib:

The maximum negative moment from span 1 with support is

Mu = 13.5 kN.m

» Determine whether the rib will act as rectangular or T – section:

For hf = 0.08 m d = 250 – 20 – 10 – 7 = 213mm

$Rn = \frac{Mu}{\emptyset bd^2} = \frac{13.3}{.9*120*213^2} =$ 2.7 MPa

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*m*Rn}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*2.7}{420}}\right) = .0069$$

A s = 0.0069(120) (213) = 176.4²> A s min = 85.2 mm²

A s = 176.4 mm² control

# of bars = As / As bar = 176.4/153.94

= 2 φ 10

157 mm²> 85.2 mm².

* Check Strain for the magnitude of under strength factor Φ:

$$a = \frac{(fy*As)}{.85*24*520} = a = \frac{(420*307.9)}{.85*24*120} = 52.8\text{mm}$$

$c = a/.85$ = 62.3mm

□s = $.003(d - c)/c$ = .0073>.005 – ok

4.6.3: Design of shear for rib:

Check for shear design:

Vu = 21.7KN

Use Φ8 with two legs d=350-20-8-4=218mm

1. 1Φvc ≥ vu

1. $1\Phi vc = 1.1 * .75 * \frac{\sqrt{24}}{6} * 120 * 218$ =23.5kN

23.5>Vu= 17.625KN

$.5 * 1.1\ \Phi V_c = 11.7$ KN < V_u =21.3 KN < 23.5 KN

No need for shear reinforcement (except for concrete joist construction)

4.7: Design of flexure for beam: -

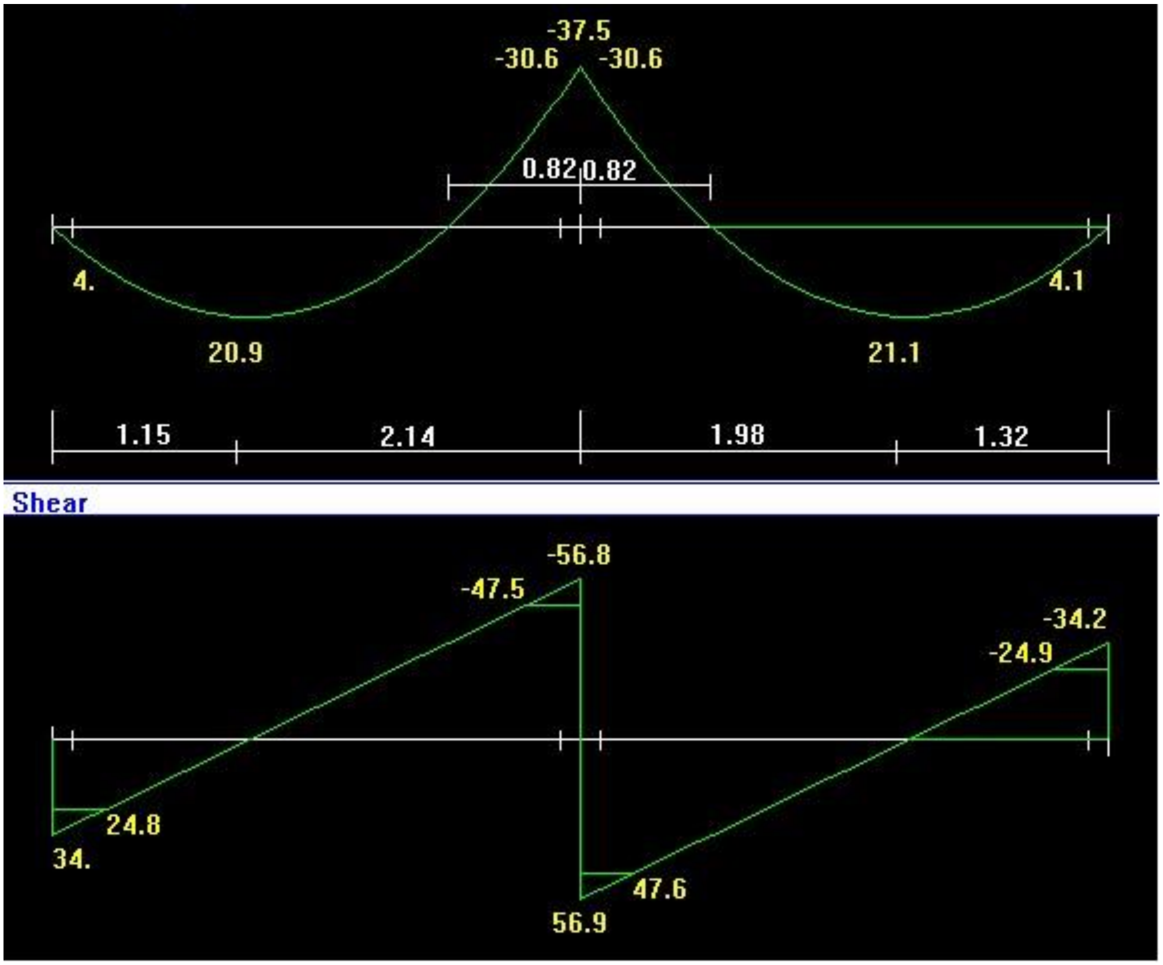


Figure (4.5) Moment and shear for beam

4.7.1: Design of positive moment:

Mu=21.1

D=250-40-8-7=195mm

C=3/7 * d= 83.57mm

B=.85

$a = B * c = .85 * 83.57 = 71.03$ mm

$Mn \max = .85 f c' ab \left(d - \left(\frac{a}{2}\right)\right)$ =120. 36KN.m

Mu=21.1 KN.m < Φ Mn =98.7KN.m

Φ = .82

Design the section as singly reinforced concrete section.

$Rn = \frac{Mu}{\emptyset b d^2} = \frac{21.1}{.9*500*195^2}$ =1.33 MPa

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*m*Rn}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*1.33}{420}}\right)$ =.00327

$A\,s = 0.00327(500)\,(195) = 318.82^2$

As min =. 25 $* \frac{\sqrt{fc'}}{fy} bwd \geq \frac{1.4}{Fy} b_w d$

As min = 284.31 mm^2

As min = 325 mm^2 – control

As < As min

Take 3 φ 12
As= 339.3 > 325 mm

$a = \frac{(fy*As)}{.85*24*500} = a = \frac{(420*339.3)}{.85*24*500} = 13.97$mm

$c = a/.85 = 16.4\text{mm}$

$s = .003(d-c)/c = .032 > .005$ – ok

Sb = 184 mm

4.7.2: Design of negative moment:

Mu = 30.6

D=250-40-8-7=195mm

C=3/7 * d= 83.57mm

B=.85

$a = B * c = .85 * 83.57 = 71.03$ mm

$Mn\max = .85 f c' ab\left(d - \left(\frac{a}{2}\right)\right) = 120.36\text{KN.m}$

Mu=30.6 KN.m < Φ Mn =98.7KN.m

Φ = .82

Design the section as singly reinforced concrete section.

$Rn = \frac{Mu}{\emptyset bd^2} = \frac{30.6}{.9*500*195^2} = 1.78\text{MPa}$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*m*Rn}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*1.78}{420}}\right) = .0044$

$A\,s = 0.0044(500)\,(195) = 390^2$

$\text{As min} = .25 * \frac{\sqrt{fc'}}{fy} bwd \geq \frac{1.4}{Fy} b_w d$

As min = 284.31 mm^2

As min = 325 mm^2 – control

As > As min

Take 4 φ 12

As= 452.38 > 390 mm

$a = \frac{(fy*As)}{.85*24*500} = a = \frac{(420*452.38)}{.85*24*500} = 18.62\text{mm}$

$? = a/.85 = 21.91\text{mm}$

s = .003$(d - c)/c$ = ..023>.005 – ok

Sb = 119 mm

4.7.3: Design of shear for Beam:

ACI – 318 – Categories for shear design:

Vu = 47.6 kN

d=h-40-8-(16/2)

= 500-40-8-(16/2)

=194mm

Vc= $\frac{1}{6}\sqrt{fc'}$ bw d = 79.70

.5 $\emptyset\, vc < Vu \leq \emptyset Vc$ - case 2

29.7 <47.6 ≤ 59.4

$Smax \leq \frac{d}{2} = 97$

$Av \min = \frac{1}{16}\sqrt{24} * \frac{500*97}{400} \geq \frac{1}{3}\ \frac{500*97}{400}$

37.12 ≥ 40.4

40.4 – control

Use Φ8 with two legs

4.8 Design of column C11

Material

Concrete B350 fc' = 24 N/mm2

Reinforcement Steel Fy = 420 N/mm

The Column is an interior one.

DL =108.45 KN

LL = 15.9KN

PD=371.2

PL=47.7

Pu = 1.2DL+1.6LL

=521.76KN

Check for slenderness

$$\frac{k \ln}{r} \leq 34 - 12\left(\frac{M1}{M2}\right) \leq 40$$

Braced frame with Mmin

K=1 for column in non-sway frames

$$\frac{k\,\mathrm{lu}}{r} \leq 34 - 12 = 22 \leq 40$$

$$\frac{k\,\mathrm{lu}}{rx} = 1 * \frac{3.69}{.3 * .3} = 38 > 22 - long\ column\ for\ bending\ about\ x - axis$$

$$\frac{k\,\mathrm{lu}}{ry} = 1 * \frac{3.69}{.3 * .55} = 22.36 > 22 - long\ column\ for\ bending\ about\ y - axis$$

Calculate the minimum eccentricity emin and the minimum moment Mmin:

emin = (15+.03h) = 15 +.03*300= 24 mm

Mmin = Pu *emin = 12.5 KN.m

Compute EI

$$Ec = 4700\sqrt{fc} = 4700\sqrt{24} = 23025MPa$$

$$Ig = \frac{bh^3}{12} = 550 * \frac{300^3}{12} = 1.2375 * 10^9 mm^4$$

$$Bdns = 1.2 * \frac{PD}{1.2D + 1.6L} = .853$$

$$EI = \frac{.4EcIg}{1 + Bdns} = 6150.77KN.m^2$$

Determine the Euler buckling load Pc;

$$pc = \frac{\pi^2 EI}{(klu)^2} = 4458.3KN$$

$$Cm = .6 + .4\left(\frac{M1}{M2}\right) = 1$$

$$\delta ns = \frac{Cm}{1 - \left(\frac{Pu}{.75pc}\right)} = 1.18 > 1$$

$$e = emin * \delta ns = 24 * 1.18 = 28.32\ mm$$

$$Mc = \delta ns\ M2 = 1.18 * 12.5 = 14.75\ KN.m$$

$$\frac{e}{h} = .09$$

$$\gamma = d - \frac{d'}{h} = \frac{300 - 2 * 40 - 2 * 10 - 25}{300} = .883$$

$$\frac{\varphi pn}{Ag} = \frac{pu}{Ag} = .458\ Ksi$$

$$\rho g = .012 > .01 - ok$$

$$Ast = \rho g\ Ag = .012 * 550 * 300 = 1980mm^2$$

Take 8 ø 20 As=2513.27 >Ast

4.8.2 Design of the Reinforcement:

S< 16 db=32 (longitudinal bar diameter) ....ACI - 7.10.5.2

Spacing S< least dim =25

Useϕ10@25 cm

4.9 Design of Stair

Material

Concrete B300 fc' = 24 N/mm

Reinforcement Steel Fy = 420 N/mm

Height = 4 m

Rise = 4 / 22=0.18m

Run = 30 cm

Live Load on Stair (Landing & Flight) =5 KN /m2

(Horizontal projection)

The following figure shows a top view of the stairs:

The structural system of the flight is shown and the following steps explain the design procedure of the flight:

1. Determination of flight thickness:

hmin = L/20

hmin = 390/20 = 20cm

∴ Select h = 20 cm, but shear and deflection must be checked:

The Stair Slope by θ = tan(θ) = 18 /30 → θ= 31°

2.Loads calculation:

Flight Dead Loads
Flight = (0.2 * 25* 1)/ cos(31) =5.833 kN/m
Plaster = (0.03 * 22* 1)/ cos(31) =0.77 kN/m
Hor.Mortar =0.03*22*1 =0.66 kN/m
Ver.Mortar = 0.03*22*($\frac{0.18}{0.3}$) = 0.396 kN/m
Hor.Tiles = 0.04*23*($\frac{33}{30}$) = 1 kN/m
Ver.Tiles = 0.03*23*($\frac{0.18}{0.3}$) = 0.414 kN/m
Triangle =0.5*0.18*25 =2.25 kN/m
Sum=11.323 kN/m

Table

<u>Live Load For Landing For 1m Strip</u> = 5*1 = 5 KN/m

<u>Factored Loads:</u>

qu= 1.2 *11.323 + 1.6*5 = 21.6 kN/m
Au= 21.6*2.4/2 = 25.92 kN

3. Analysis: **The following figures show shear and moment Diagrams resulted from analysiof the flight**

4. Design Of Shear For Flight:

Assume bar diameter (ø 14) for main reinforcement:

d=200-20-(14/2) = 173 mm

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

$$= 0.75 * \frac{1}{6} * \sqrt{24} * 1000 * 173$$

=105.94 kN

0.5 Ø×Vc = 52.97 kN

∴ No Shear Reinforcement is Required#

of Bending Moment for Flight :- (Mu=46.305 KN.m)

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

$$\rightarrow kn = \frac{Mu/\emptyset}{b*d^2} = \frac{46.305*10^6/0.9}{1000*173^2} = 1.72 \text{ MPa}$$

$$\rightarrow \rho = \frac{1}{m} * (1- \sqrt{1 - \frac{2*KN*m}{Fy}}) = \frac{1}{20.6} * (1- \sqrt{1 - \frac{2*1.72*20.6}{420}}) = 0.0043$$

$$\rightarrow Asreq = \rho * b * d = 0.0043 * 1000 * 173 = 741.20 mm^2$$

$$\rightarrow As\ min = 0.0018 *1000*200 = 360\ mm^2$$

∴ Select Ø14/25 with As = 769.5 mm^2 > As req …. For Main Reinforcement

Check for Spacing :-

S = 3h = 3*200 = 600 mm.
S = 450 mm.
S = 380 (280/fs) – 2.5 Cc < S = 380 (280/fs)
= 380 (280/280) 2.5*20 = 330 mm < 300 mm.
S = 250 < 300 OK.

For secondary Reinforcement select Ø12 /30 with As=452.16 mm^2 /m = As min

Check for Spacing :-

S = 5h = 5*200 = 1000 mm.
S = 450 mm.
S = 300 < 450 OK

Check for strain:

C = T

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

0.85*24*a*1000 = 769.5 *420

a = 15.84 mm → C = a/β = 15.84/0.85 = 18.64 mm

$\varepsilon_s = 0.003(\frac{d-C}{C}) = 0.003\,(\frac{173*18.64}{18.64})$

∴ ε_s **= 0.025 > 0.005 …. Ø = 0.9 (OK).**

4.9.2 Design of Landing:

Determination of Thickness: -

hmin = L/20

hmin = 390 /20 = 19 cm

∴ Select h = 20 cm , but shear and deflection must be checked

Load Calculation: -

Dead Load For Landing For 1m Strip:-

Landing Dead Loads
Tiles = 0.03*23*1=0.7 kN/m
Mortar = 0.03*22*1=0.4 kN/m
Sand = 0.07*18*1=1.26 kN/m
Slab = 0.12*25*1=5 kN/m
Plaster = 0.02*22*1=0.4 kN/m
Sum = 7.76 kN/m

Live Load For Landing = 5*1 = 5 KN/m

Factored Load For Landing :-

W_U = **1.2*7.76+1.6*5 = 17.312 kN/m**

Factored Load From Flight :-

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

W_R = **Rs_1/B = 25.92/1.1 = 23.56 kN/m**.

d= 200-20-(14/2) = 173mm

Vumax= (17.312*3.9)/2 – (23.56*1.8) = 84.07 kN

→ Shear Force Design :

d=173mm & Vu max=84.07 kN

$$\text{Ø}\times Vc = 0.75 * \frac{1}{6} * \sqrt{24} * 1000 * 173 = 105.94 \text{ kN} > Vu \max = 84.07 \text{ kN}$$

∴No Shear Reinforcement is Required#

→ Bending Moment Design : (Mu max = 72.13 kN.m)

- **m** = 20.6
- **kn** = $\frac{72.13 * 10^6 / 0.9}{1000 * 173^2}$ = **2.41 MPa**
- $\rho = \frac{1}{20.6} * (1 - \sqrt{1 - \frac{2*2.41*20.6}{420}}) =$ **0.0061**
- **Asreq** = 0.0061 ∗ 1000 ∗ 173 = 1055.3 **mm^2**
- **As min = 0.0018 *1000*200 = 360 mm^2**

∴ Select Ø14 /15cm with As = 1077.3 mm^2 / m > As req …. For Main Reinforcement

Check for Spacing:-

S = 3h = 3*200 = 600 mm.
S = 450 mm.
S = 380 (280/fs) – 2.5 Cc < S = 380 (280/fs)
= 380 (280/280) 2.5*20 = 330 mm < 300 mm.
S = 150 < 300 OK.

For secondary Reinforcement select Ø12 /30 with As=452.16 mm^2 **= As min**

Check for Spacing:-

S = 5h = 5*200 = 1000 mm.
S = 450 mm.
S = 300 < 450 OK.

Check for strain:-

C = T
0.85*fc'*a*b = As*fy

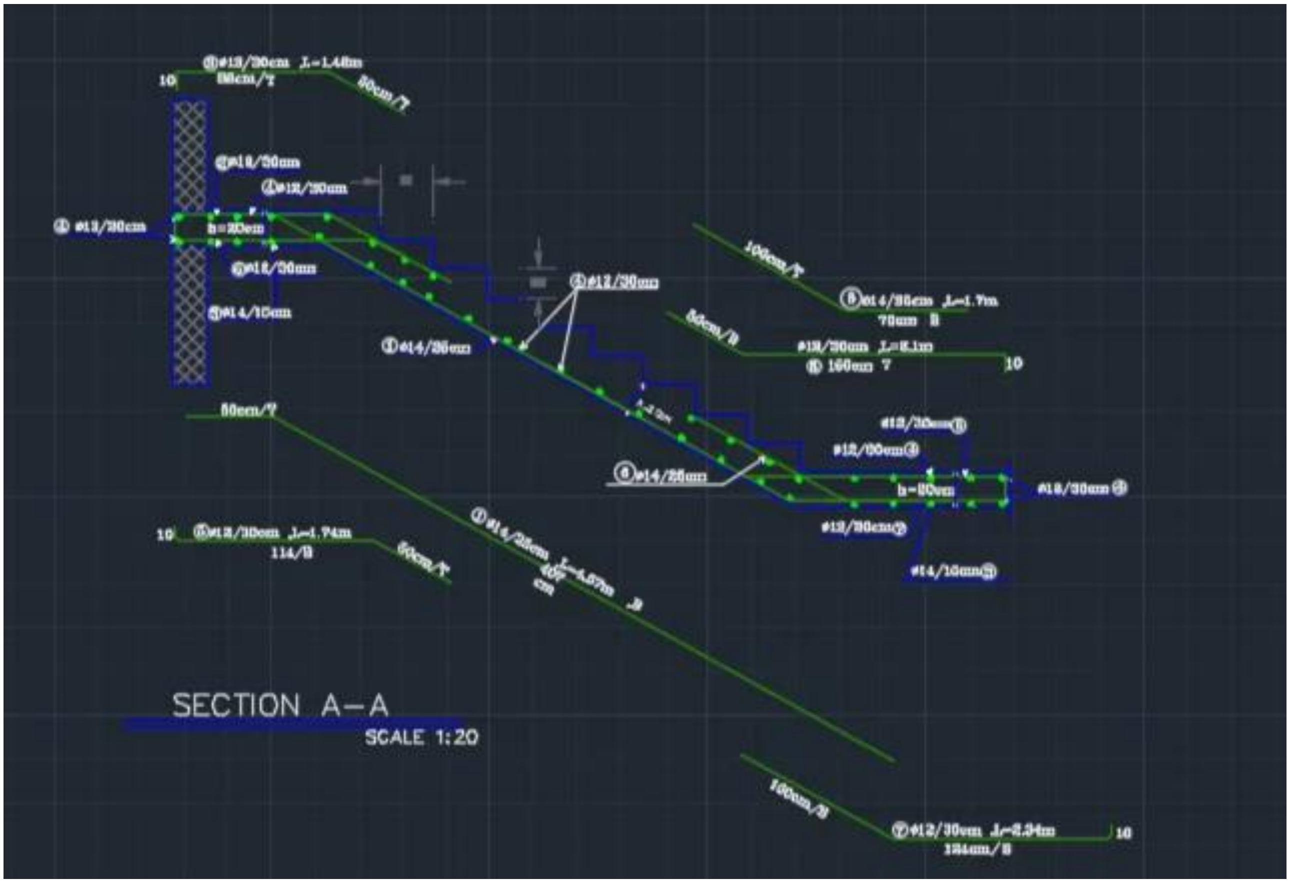
0.85*24*a*1000 = 1077.3 *420

a = 22.18 mm → **C = a/β = 22.18/0.85 = 26.09 mm**

$\varepsilon_s = 0.003(\frac{d-C}{C}) = 0.003 (\frac{173*26.09}{26.09})$

$\therefore\ \varepsilon_s$ **= 0.017 > 0.005 …. Ø = 0. 9** (OK).

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


SECTION A—A
SCALE 1:20

4.10: Design footing

✓ Material: -

concrete B300 $Fc' = 24\ N/mm^2$

Reinforcement Steel $Fy = 420\ N/mm^2$

Load Calculations: - (From Column C3)

Dead Load = 500Kn, Live Load = 100 Kn

Total services load = 500 + 100 = 600 Kn

Total Factored load = 1.2*500 + 1.6*100= 760 Kn

Column Dimensions (a*b) =50*35 cm

Soil density = 18 Kg/cm3

Allowable Bearing Capacity = 400 Kn/m2

Assume h = 50cm $q_{net\,allow}$ = 400 –18*0.25-25*0.50 =

384.9kn/m2

Area of Footing: -

$$A = \frac{Pt}{q_{net\,allow}} = \frac{604.01}{384.9} = 1.57\ m^2$$

Assume Square Footing

B required =1.35 m Select B = 1.35m

Bearing Pressure: -

q_u =750.55/1.35*1.35 =417Kn/m^2

Design of Footing: -

4.10.1Design of One Way Shear Strength: -

Critical Section at Distance) d (From The Face of Column

Assume h = 50cm, bar diameter ø 12 for main reinforcement and 7.5 cm Cover d = 500 – 75 – 10 = 415 mm

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

$$Vu = 415\left(\left(1.35 * \frac{.30}{2} - .415\right) * 1.35 = 61.9 \text{ Kn}\right.$$

$$ø.Vc = .75 . \frac{1}{6} * \sqrt{fc'} * b_w * d$$

$$ø.Vc \; 0.75* \; - * \sqrt{\;} 24 *1350* 415 = 343Kn$$

ø.Vc> Vu
so *Safe*

4.10.2 Design of Two Way Shear Strength: -

$Vu = Pu - FR_b$

$FR_{b=}\ q_u$ **area of critical* sec

$Vu = 760\text{-}417\left[(0.55 + 0.415) *(0.3+ 0.415)\right] = 691.9Kn$

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

$\varnothing.V_{c} = \varnothing\frac{1}{6}\left(1+\frac{2}{Bc}\right)\sqrt{fc}$ b d

$\varnothing.V_{c} = \varnothing\frac{1}{12}\left(2+\frac{\alpha s}{b0/d}\right)\sqrt{fc}$ b d

$\varnothing.V_{c} = \varnothing\frac{1}{3}\sqrt{fc}$ b d

Where:-

$$\beta c \quad \frac{Column\ Length\ (a)}{Column Width\ (b)} \quad \frac{55}{30} = 1.8$$

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

b_o = 2*(41.5+55) + 2*(41.5+30) = 336cm

αs = 40 for interior column

ΦVc =1707.7 Kn<Vu=691.9 -Kn

4.10.3:Design of Bending Moment: -

At long direction

Critical Section at the Face of Column

Mu = 417*1.35*0.4*0.4/2 = 45.66 kn.m

R_n=.22 Mpa

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

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.328}{420}}\right) = 0.00102$$

$A_{s,req} = \rho.b.d = 0.001 \times 1350 \times 415 = 560.25\ mm^2$

$A_{s,min}$ = 0.0018*1350*415= 1008.45 mm^2

$A_{s,req} < A_{s,min}$ 1008.45 mm2

As,min =1008.45mm……… is control

Check for Spacing :-

S = 3h = 3*50 = 150cm

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

S = 45 cm **……… is control**

Use 13ø10in Both Direction, $A_{s,provided}$= 1.021mm^2>$A_{s,required}$= 1.008mm^2… Ok

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{413-55}{55}\right) = 0.019 > 0.005 \ \ldots\ldots \mathbf{0}\boldsymbol{k}$$

Moment at short direction:

Critical Section at the Face of Column

Mu = 417*1.35*0.525*0.525/2 = 77.7 kn.m

$R_{n=.37}$

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

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.42}{420}}\right) = 0.0013$

$A_{s,req} = \rho.b.d = 0.0013 \times 1350 \times 415 = 728.3 \text{ mm}^2$

$A_{s,min} = 0.0018*1350*415 = 1008.45 \text{mm}^2$

$A_{s,req} < A_{s,min}$ 1008.45 mm2

As,min ……… is control

Check for Spacing :-

S = 3h = 3*50 = 150cm

$S = 380* \left(\frac{280}{\frac{2}{3} * 420}\right) - 2.5*75 = 192.5 \text{ cm}$

S = 45 cm ……… **is control**

<u>Use 14ø10in Both Direction, $A_{s,provided}$</u>

Check for strain: -

$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{413-55}{55}\right) = 0.019 > 0.005 \ \ldots\ldots \mathbf{0k}$

4.10.4: Design of Dowels: -

Load Transfer in Footing: -

$\emptyset Pn.b = \emptyset(0.85 fc A_1 \sqrt{\frac{A2}{A1}}$

$A_1 = 55 * 30 = 0.165\ m^2$
$A_2 = 135 * 135 = 1.82\ m^2$

=4375.8KN > 760

No Need for Dowels

Load Transfer In Column: -

$\emptyset Pn.b = \emptyset(0.85 fc A_1 = 2187.9\ KN > 760$ ok

No Need for Dowels

As,min = 0.005 * Ac = 0.005 * 550 *300 = 825 mm2

Use 12ø16, $A_{s,provided}$= 2411.5 mm^2 > $A_{s,required}$ 825mm^2… Ok

4.10.5 Development Length In Footing: -

Tension Development Length In Footing :-

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

$Ktr = 0\ (Nostripes)$

$cb = 50 + \frac{16}{2} = 58mm\ \ Or\ cb = \frac{110}{2} = 55\ mm$

$\frac{ktr + cb4}{db} = \frac{0 + 55}{16} = 3.4 > 2.5$

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

Chapter Five

Results and Recommendations

5.1 RESULT

5.2 RECOMMENDATIONS

5.1 Results

1 Each student or designer must be able to design manually, so he or she can use design programs.

2 The natural factors surrounding the building, the nature of the site and the impact of natural forces on the site are factors that must be considered.

3 The most important steps of structural design, how to connect the various structural elements through the overall view of the building, and then divide all of these elements to design individually. 4 One-Way Ribbed Slab has been used in most slabs due to the shape of building. Solid Slab and flat slab system was also used.

5 Software programs Used:

There are several computer programs used in this project:

a) AUTOCAD 2010/2007: for detailing drawings of structural elements.

b) ATIR: Structural design and analysis of structural elements.

c) Microsoft Office : It was used in various parts of the project such as text writing, formatting and project output.

d) Etabs for the design and reinforced Shear Walls).

e) Safe design of solid and flat slabs and foundations.

6 The live loads used in this project were from the Jordanian Code.

5.2 Recommendations

This project has a major role in expanding and deepening our understanding of construction projects with all the details, analyzes and designs. Here we would like to offer recommendations, which we hope that will benefit those who are planning to choose projects of a structural nature. Initially, all architectural plans must be coordinated and prepared, so that the building materials are selected and the structural system of the building is determined. At this stage, the overall information about the site, soil and the soil strength of the site must be provided through a geotechnical report. Then the locations of the basement and shear walls and columns will be determined with architectural engineering team. At this stage, the structural engineer tries to obtain as many shear walls as possible, and

distributed them regularly throughout the building; that will be used to resist earthquakes and other horizontal forces