Structural Design for Dora Hospital

By

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DIDICATION

To Palestine…

To our Parents….

To The Soul of Martyrs….

To our Teachers ….

To our Friend's …

To whom we Love ….

To Everyone who gave us Help …

To DR. Belal Almassri …

Team Work

ACKNOWLEDGMENT

We would like to thank and gratitude to Allah, who gives us the most Merciful who granted us the ability and willing to start project.

We thank "Palestine Polytechnic University", "Department of Civil and Architectural Engineering" and wish to it more progress and successes. We express our thanks to Eng. Belal Almassri, who gave us the knowledge, valuable help, encouragement, supervision and guidance.

Thanks for all teachers that gave us a little of theirs time and answers our questions.

Finally, our deep sense and sincere thanks to our parents, brothers and sisters for their patience, and for their endless support and encouragement also for everybody who tried to help us during our work and gave us strength to complete this task.

Team Work

ABSTARCT

Government and private hospitals are one of the most important institutions that serve our country and serve our people. They provide services and health care to them and provide them with the necessary treatment requirement It is necessary from all diseases, especially because we are suffering today from an increase in the population and the services and treatment that it requires all sides.

The project is a hospital in the city of Dura, it is a city with a large population so that it needs a hospital to serve this number of residents, as health centers in the city have become unable to meet the needs of this population and there has been a trend from the government several years ago this construction the hospital.

The project consists of 5 floors

*Two level floors, each with an area of 726 m 2.

*The ground floor area is 3667 m 2.

*The first floor has an area of 1893 m 2.

*The second floor has an area of 1881 m 2.

*The total project area is 8893 m 2.

*The land area required for the hospital must not be less than 11,000 square meters.

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List of Abbreviations:

- **Ac** = area of concrete section resisting shear transfer.
- **As** = area of non-prestressed tension reinforcement.
- **Ag** = gross area of section.
- **Av** = area of shear reinforcement within a distance (S).
- **At** = area of one leg of a closed stirrup resisting tension within a (S).
- **b** = width of compression face of member.
- **bw** = web width, or diameter of circular section.
- **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.
- **I** = moment of inertia of section resisting externally applied factored loads.
- **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.
- **Ld** = development length.
- **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.
- **Vn8** = nominal shear stress.
- **Vs** = nominal shear strength provided by shear reinforcement.

Vu :factored shear force at sec.

Wc : weight of concrete (Kg/m^3)

CHAPTER

1

INTRODUCTION

1.1 INTRODUCTION.

1.2 RESEARCH PROBLEM

1.3 AN OVERVIEW OF THE PROJECT

1.4 THE OBJECTIVE OF THE PROJECT

1.5 PROJECT STEPS

1.6 REASONS TO CHOOSE PROJECT

1.7 THE SCOPE OF THE PROJECT

1.8 SCHEDULE

1.1 Introduction

Human nature needs to have places of worship in place of residence, and these places must have all the means to ensure comfort and safety. General design process requires the introduction of all aspects of the building to be created both in the architectural appearance of the building and how to distribute the spaces and areas within various service sections linked to each other, or structural terms dealing with structural system capable of carrying the loads affecting the building taking into account the minimum possible economical system construction as is compatible with the architectural design choice.

The project includes the architectural and structural design of Theater, Library, Management rooms, Galleries, Mosque, Restaurant, Conference Hall Lecture halls, Stores, Computer halls and Concerns literal. Distributing columns and bridges in line with architectural and design elements from components to bases and foundations and structural schemes and processing in order to produce an integrated project and implementation.

1.2 Research Problem:

The summary of the idea of this project, is to prepare a structural design of a general hospital , consisting of all facilities that should be available in any optima medical center . This building is consisting of 5 floors with a nice elevation, which reflecting the medical face of the building, on the other hand , no doubt that the structural design at a same level of importance of archeries one ,by supporting the building with a structural element ,which will be designed according to ACI code. The project contains the structural analysis for vertical and horizontal loads and the structural design and details for each member in the building.

1.3 An Overview of the Project:

The project is a hospital in the city of Dura, it is a city with a large population so that it needs a hospital to serve this number of residents, as health centers in the city have become unable to meet the needs of this population and there has been a trend from the government several years ago this construction the hospital.

The project consists of 5 floors

Two level floors, each with an area of 726 m 2.*

The ground floor area is 3667 m 2.*

The first floor has an area of 1893 m 2.*

The second floor has an area of 1881 m 2.*

The total project area is 8893 m 2.*

The land area required for the hospital must not be less than 11,000 square meters.*

1.4 The Objective of the Project

The objectives of the project are divided into two parts:

1. Architectural Goals:

In this project architectural design is not the main goal as civil and building engineers, however this buildings where necessary to achieve beauty and utility requirements, cost and durability in these facilities, which are the basic architectural design requirement.

2. Structural Goals:

Structural design of the units will be done in this project with prepare all structural drawings for beams, slabs, columns, footings and shear walls to be ready for fulfillment on the location of the project

1.5 Project Steps

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 Reasons to Choose the Project:

The reason of selecting the project back to several things, including the conquest of skill in design for structural elements in buildings, in addition to increasing knowledge of machine construction systems in our country and other countries, as well as the conquest of scientific knowledge and the process followed in the design and implementation of construction projects and the structural engineer after graduation in the work market in the future.

This search is to submit it to the department of civil engineering and architecture at the College of engineering and technology at Palestine Polytechnic University to meet graduation requirements and a Bachelor's degree in civil engineering for building engineering.

1.7 The scope of the Project

This 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.

1.8 Schedule:

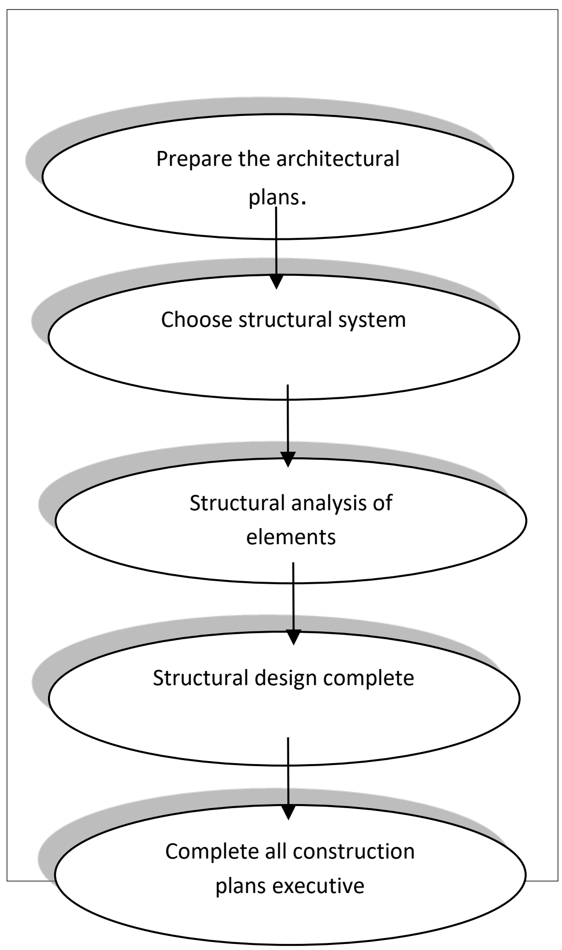


Figure (1-1): Shows The Stages of The Project.

Table (1.1): Project Schedule.

Week NO. / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
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

2

Architectural Description

2.1 INTRODUCTION.

2.2 THE MAIN ELEMENTS IN THE ISLAMIC CULTURAL CENTER.

2.2.1 INTERIOR SPACES.

2.2.2 EXTERNAL SPACES

2.3 PROJECT PLANS.

2.4 PROJECT ELEVATIONS.

2.5 PROJECT SECTIONS.

2.6 SOME PERSPECTIVE SHOTS FOR THE ISLAMIC CULTURAL CENTRE.

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 Project overview:

Through wandering on our Palestinian street, and the cover revealed its concerns, we find the need for our society With model hospitals, you keep in mind the modern requirements of public health and safety systems. The urgent need for hospitals in our area, the current medical deficit in the country, will be the solution .

The idea of the project is summarized by designing a general hospital that achieves the goals mentioned above and meets All the needs that the Palestinian family demands, as the project consists of three floors in addition to two settlement levels, ranging in area from about 726 square meters to 3667 square meters, and the total area is 8,893, in which the career services vary appropriately with the required design need.

2.3 Study the project components :

2.3.1 Plans :

The project includes five floors, with a variety of services, on each floor distributed according to the following:

- Second Basement: It contains the morgue.

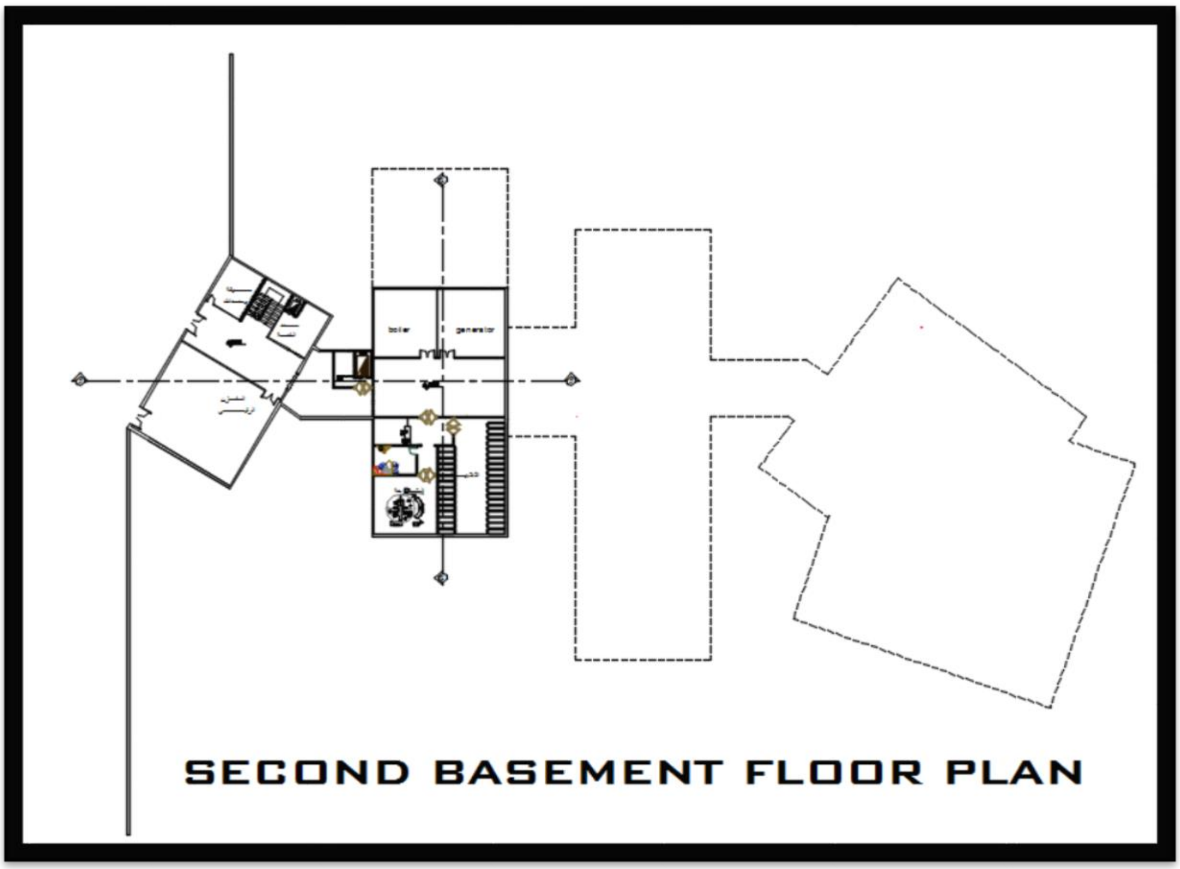
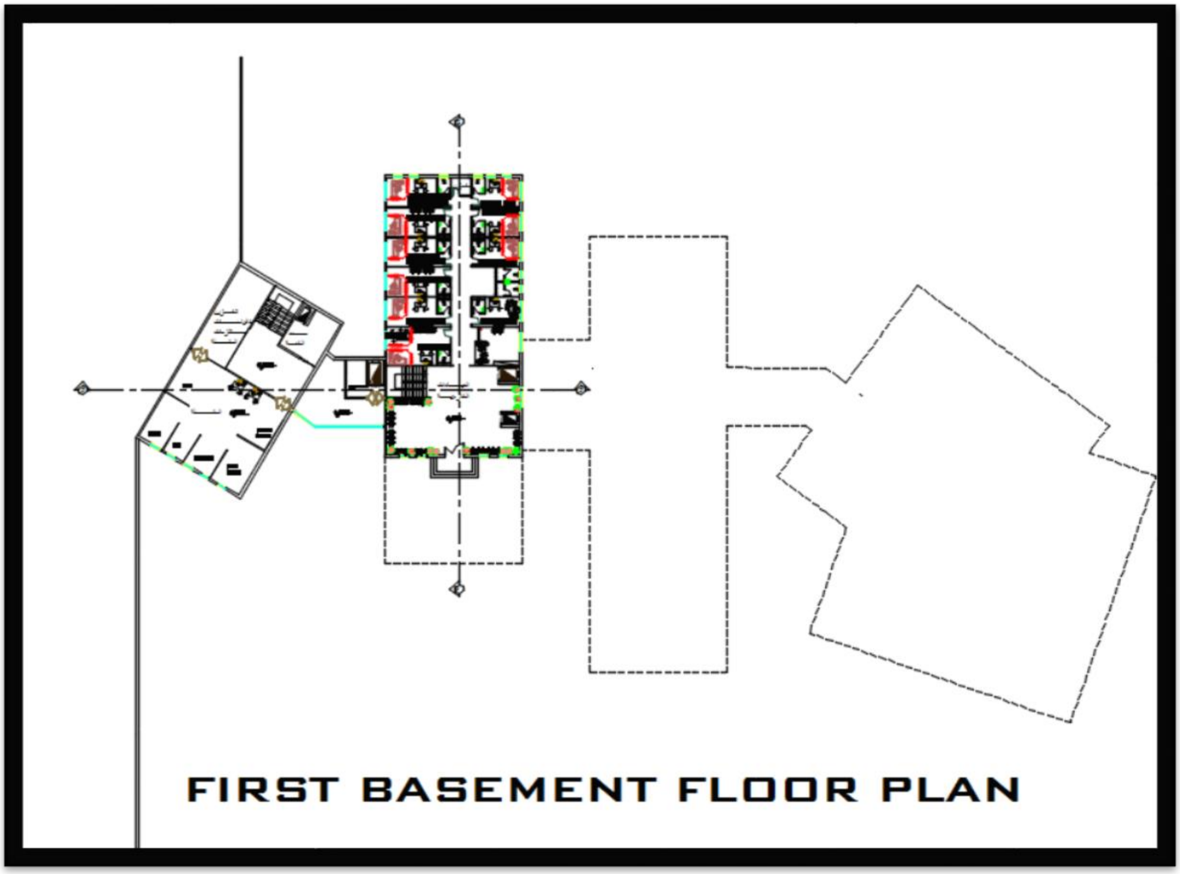


Figure (2.1): second basement plan

- First Basement Floor : It contains
  1. Washing machine
  2. Outpatient clinics



(2.2) : Figure first basement plan

- Ground Floor : It has an area 3667 m 2

  It Contain :

  1. Kitchen.
  2. x_ray place.
  3. Orthopedic department.
  4. children section.
  5. Emergency department.

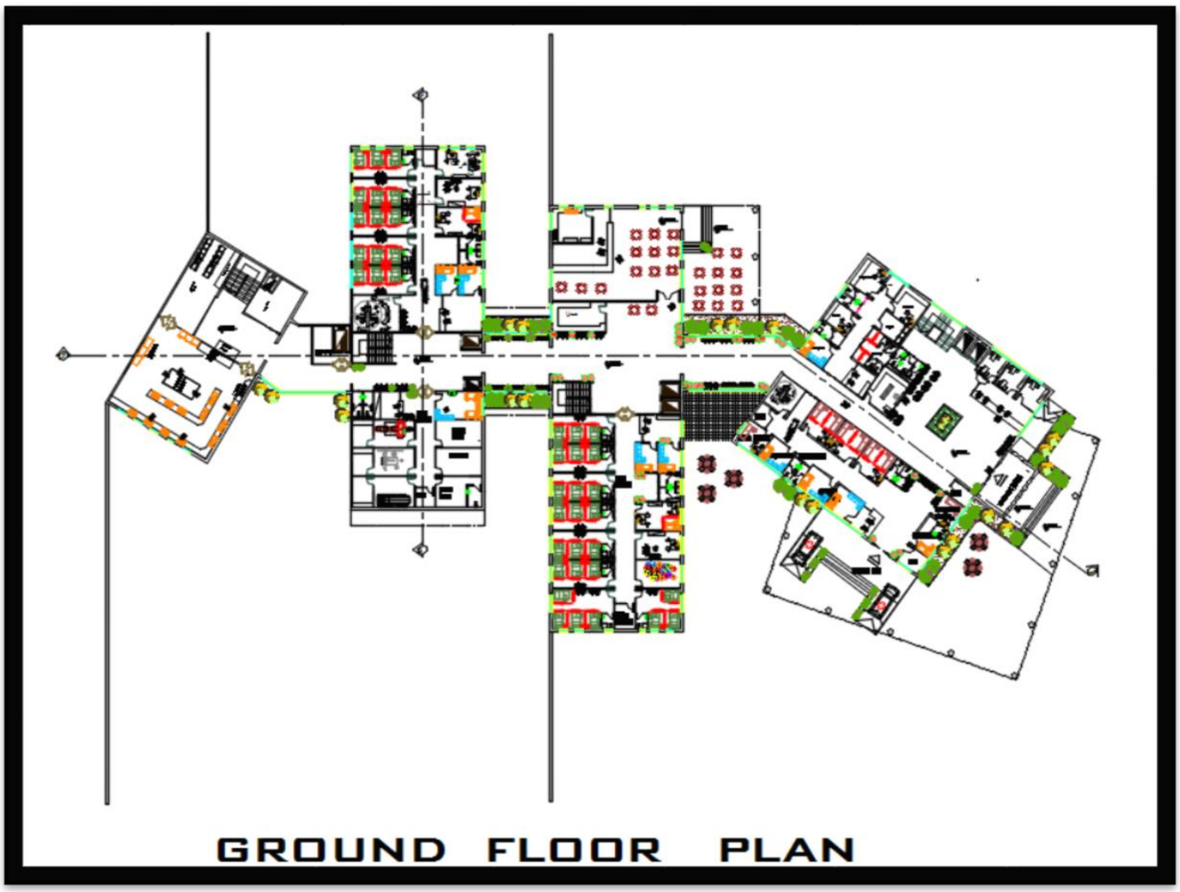
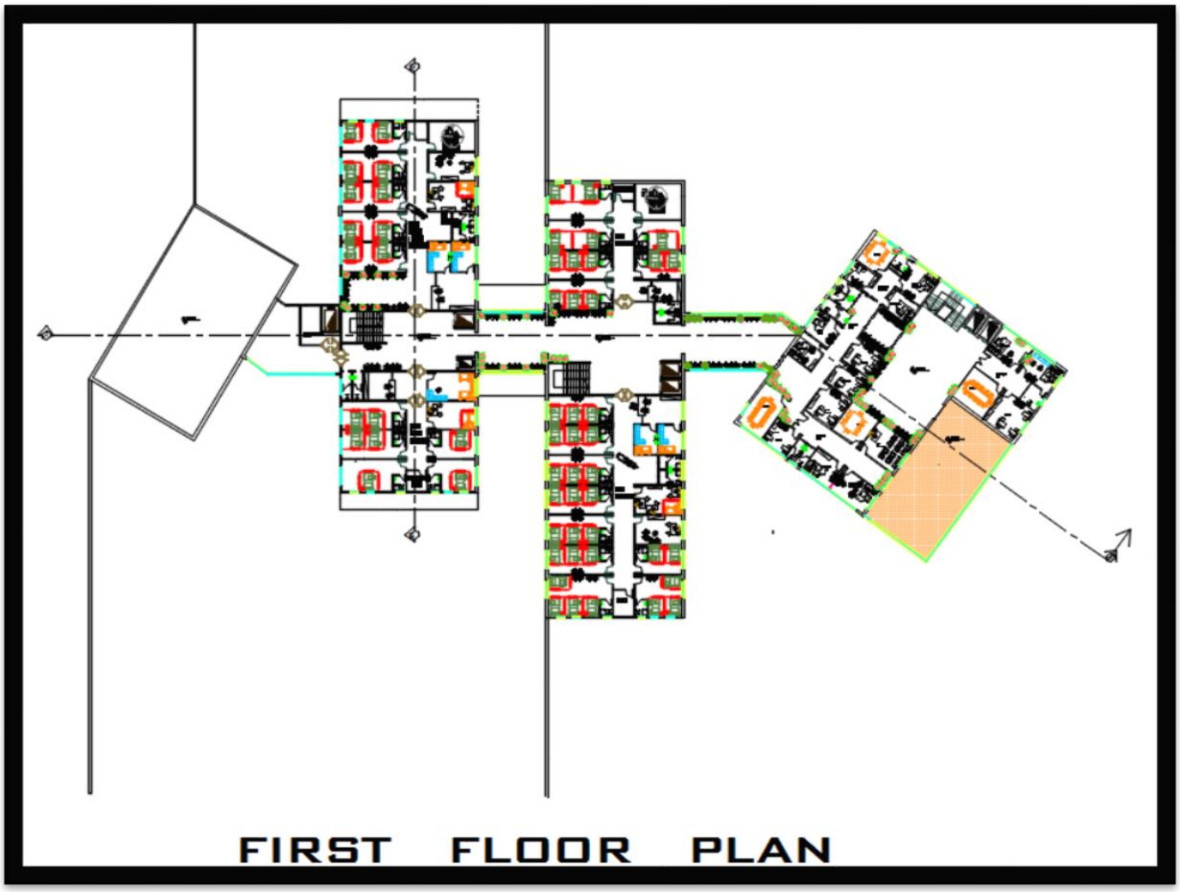


Figure (2.3) :Ground floor plan

- First Floor: It has an area 1893 m 2.

  It Contain:

  1. Department of ENT.
  2. Quarantine department.



Figure(2.4) : First Floor Plan

- Second Floor **:** It has an area 1881 m 2.
  It Contain:

  1. Department of Medical Director.

  2. The esoteric section.

.

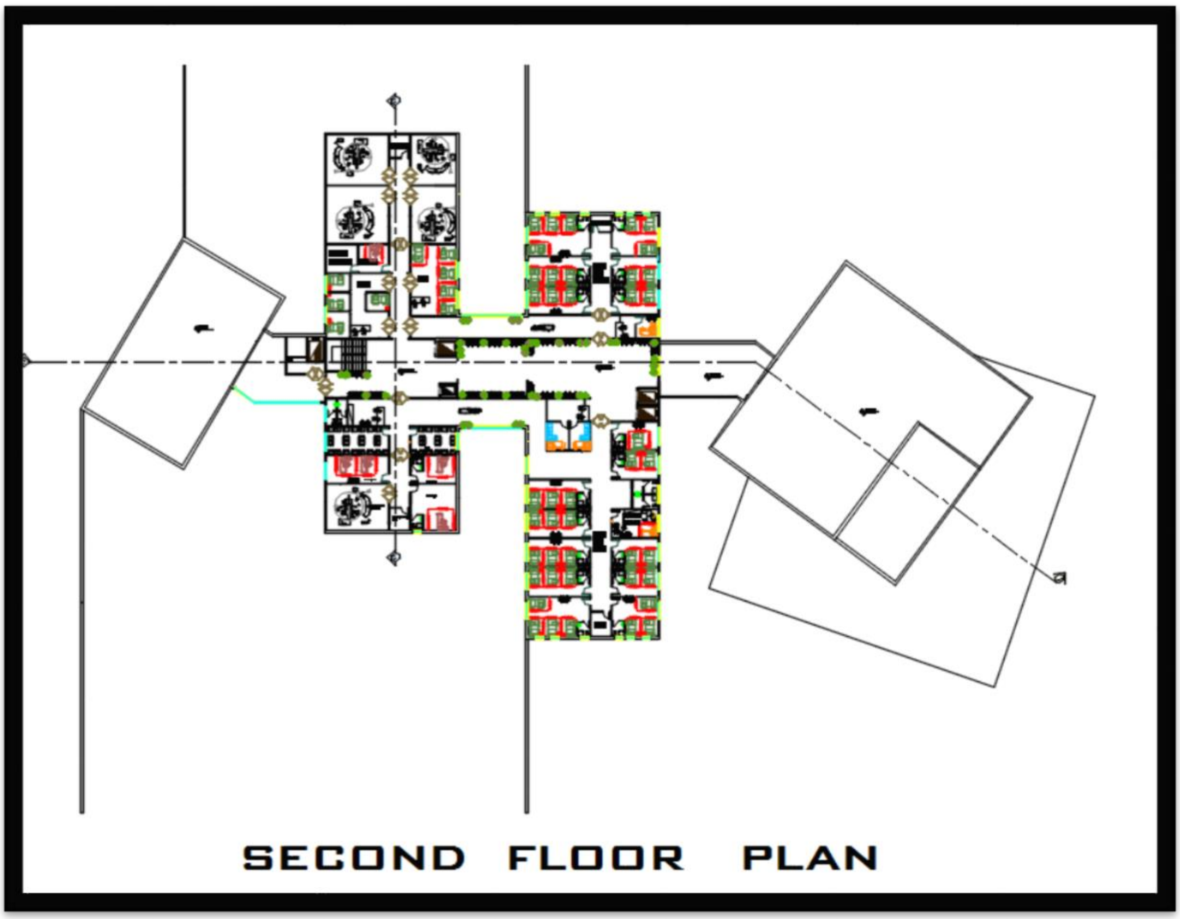


Figure (2.5) :Second floor plan

2.3.2 Description of Elevation

The main materials used in the construction process are reinforced concrete, and ordinary concrete .And two types of stone are stained stone and Al-Matabba stone (sesame stone), provided that they are suitable for conditions. Resist weather conditions and provide beauty, where stained stone is used in The facades, and the stone bricks above the windows, doors and plaques.

- **North east Elevation**

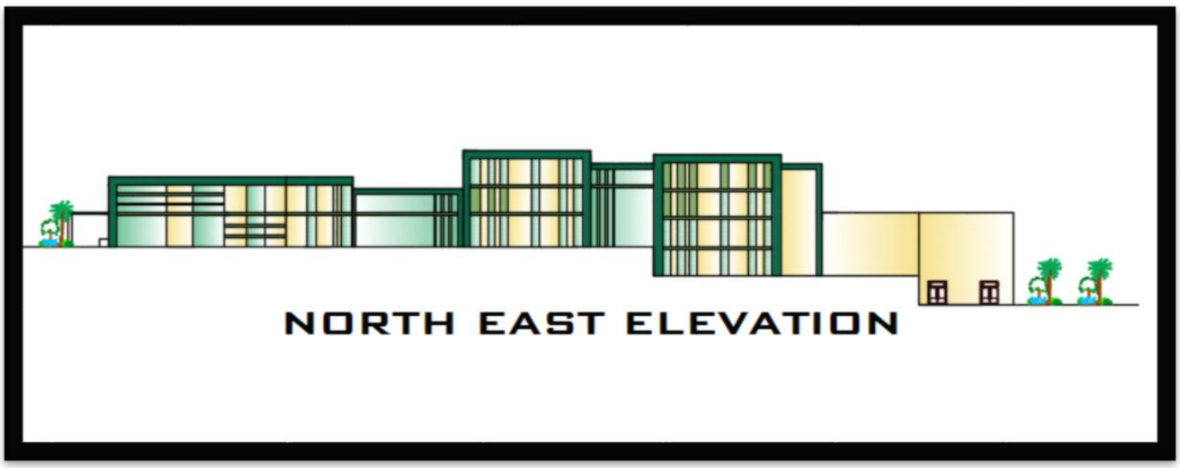


Figure (2.6): North East Elevation

- **South west Elevation**

Figure (2.7) :South West Elevation

- **North West Elevation**

Figure (2.8) :North West Elevation

- **South east Elevation**

Figure (2.9) :south east elevation qw

2.3.3 The Movement in the Building

There are many forms of movement in the building, as comfort, safety and ease of movement were taken into consideration. Which externally is to reach the hospital and internally by horizontal and vertical movement.

- **Section A-A**

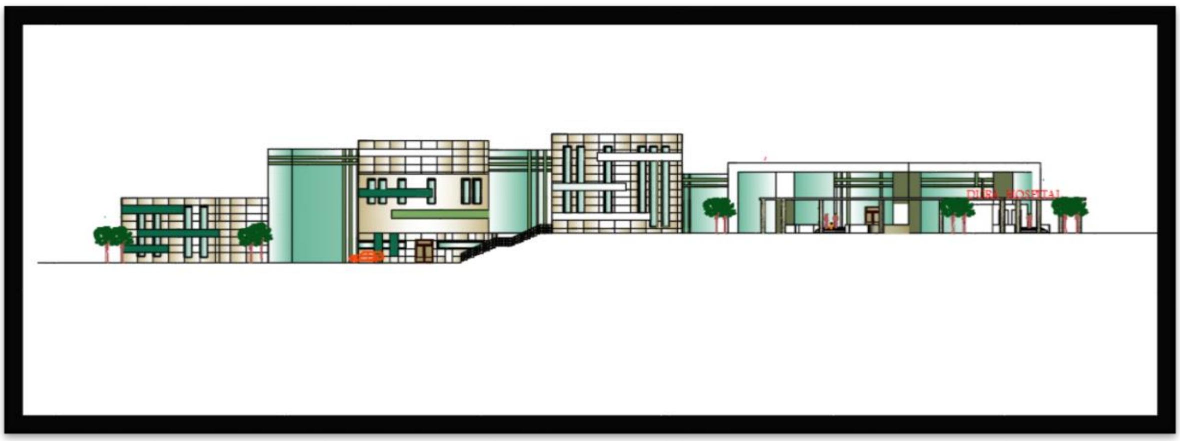


Figure (2.10): Section A-A

- **SECTION B-B**

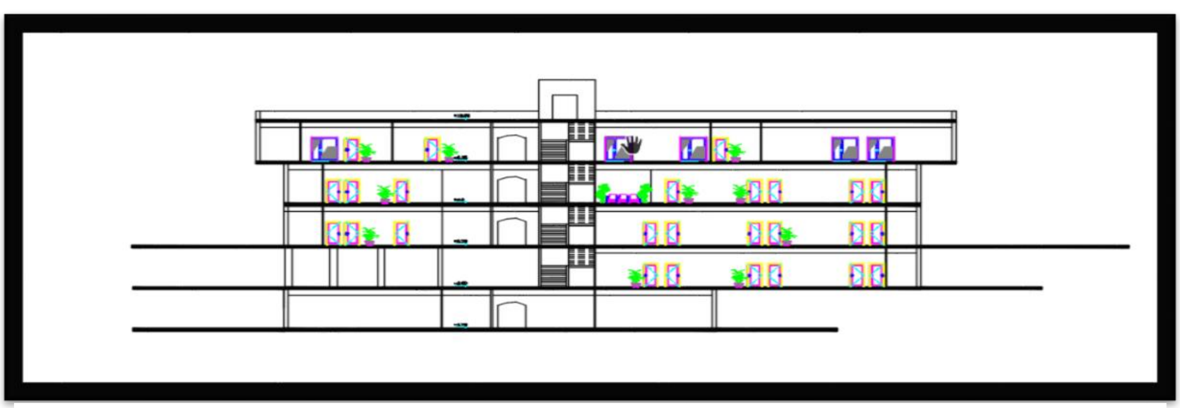


Figure (2.11) :Section B-B

- **SITE PLAN**

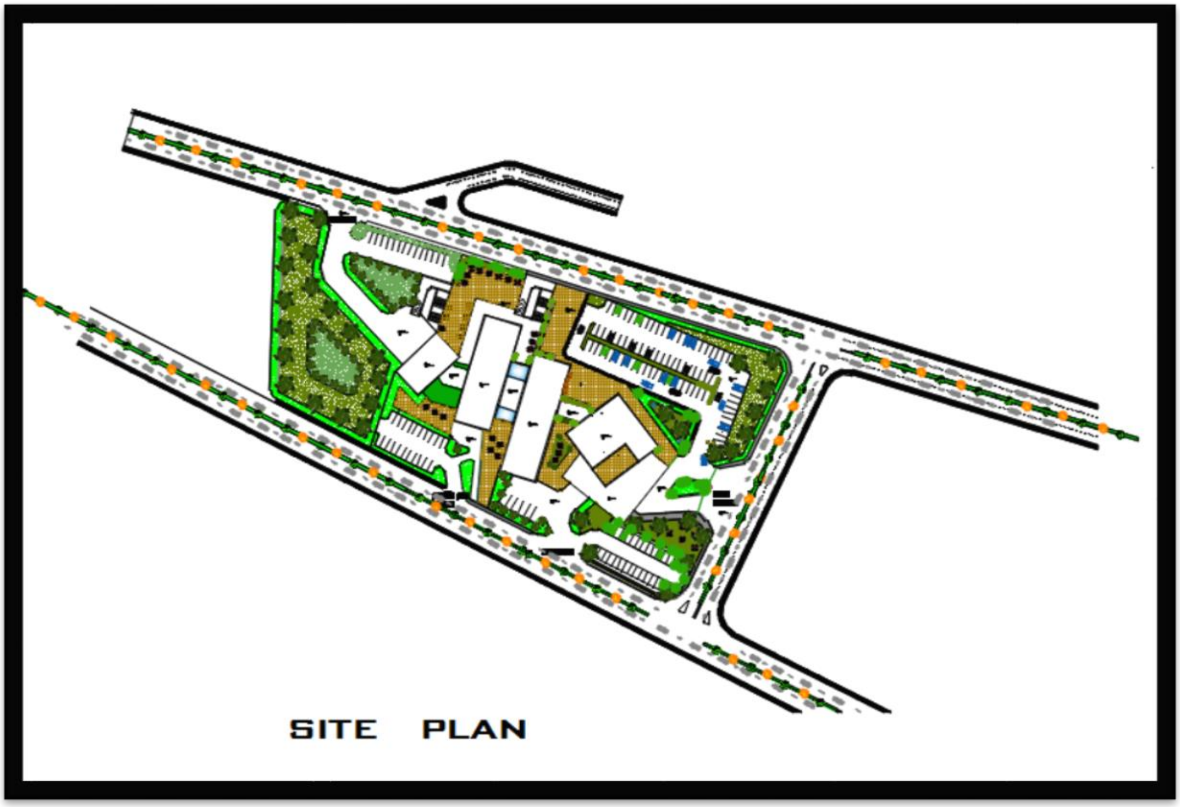


Figure (2.12) :Site Plan

CHAPTER

3

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.

3.6 STRUCTURAL ELEMENTS OF THE BUILDING.

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 Goal 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 by the appropriate International Center for Geotechnical Engineering Studies (ICGES) in Bethlehem, and took samples of the soil, has been getting the value soil durability of Earth-based project.

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 is 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 reflect negatively on 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 extensions, as well as suspended ceilings and decorations for the building.

الجدول (٣-١-ب)

تابع الأحمال الحية للأرضيات والعقدات

نوع المبنى		الاستعمال	الحم ل الم وزع	الحمل المركز البديل
ع ام	خاص	الاشغ ال	كن/م٢	كن
تابع مباني التجمعات العامة.	تابع القاعات، قاع ات الاجتماعات، المطاعم، المتاحف، المكتبات،	المم . رات والم . داخل والأدراج و. . . سطات الأدراج والممرات المرتفعة الموصلة بين المباني.	4.0	4.5
	النوادي، المسارح، ستوديوهات الاذاعة.	المنص . ات.	7.5	4.5
		أرضي ات المتاح ف وصالات عرض الفنون.	4.0	4.5
		أماكن العبادة (الم ساجد والكنائس).	3.0	2.7

Figure (3-1) Determination of live load code (page 25)

Snow Loads:

Figure (3-2): snow loads.

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

حمل الثلـ ـج (S_o) (كن/م٢)	ارتفاع المنشأ عـ ـن سطح البحر (h) (بالمتر)
0	250 > h
(h-250)/800	500 > h > 250
(h-400)/320	1500 > h > 500

Figure (3.3): Determination of snow loads code (page 44).

Based on the scale of previous snow loads and after selecting the high building surface and that equals (700 m) according to item III snow load is calculated as follows:

SL= (h-400)/320

SL= (775-400)/320= 1.17KN/m^2

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 in a building on the construction accounts.

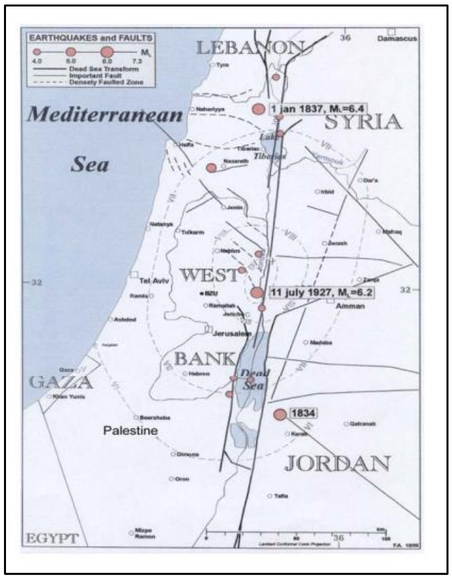


Figure (3-4): Earthquake map for Palestine.

Wind 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.

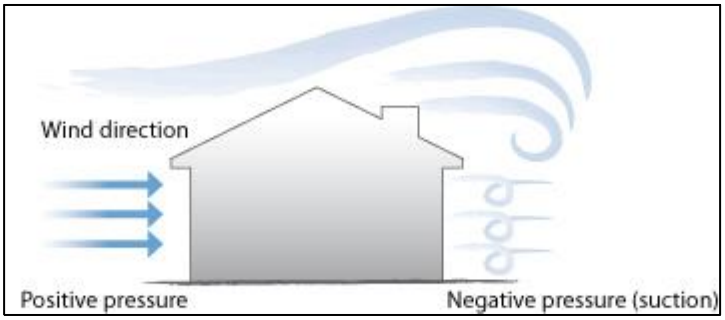


Figure (3-5): Wind Pressure on buildings.

3.6 Structural Elements of the Building:

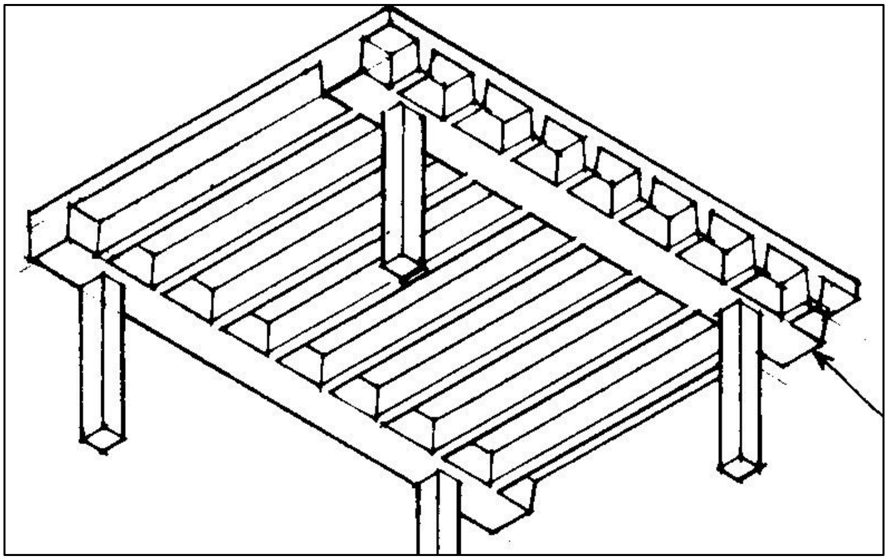
All buildings are usually consists of a set of structural elements that work together to maintain the continuity of a building and its suitability for human use, and the most important of these slabs and beams and columns and load-bearing walls, etc.

- **Slabs:**

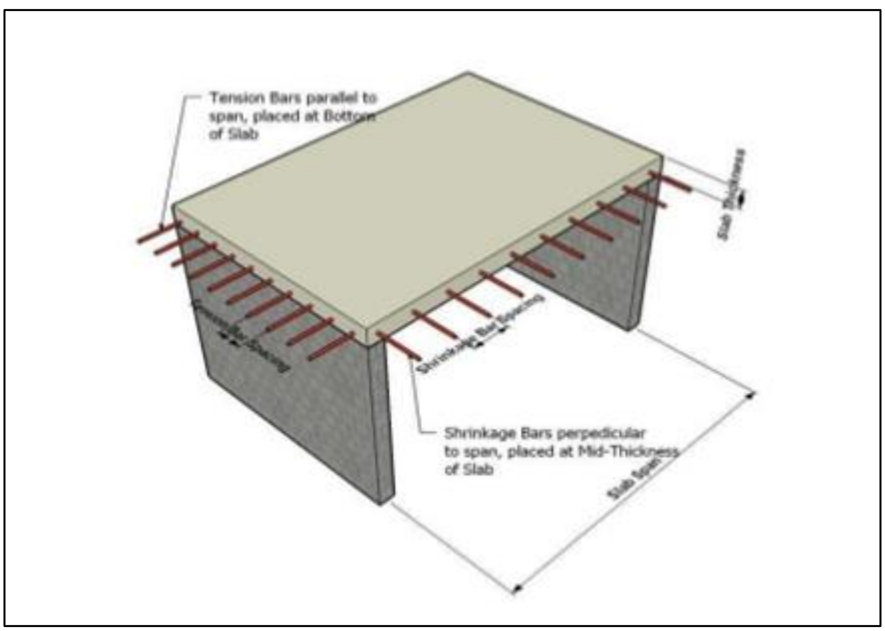
Structural elements are capable of delivering vertical forces due to the loads affecting the building's load-bearing structural elements such as beams, columns and walls, without distortions.

In this project, two types of components both in its appropriate place, and in, which will clarify the structural design in the subsequent chapter, and below these types:

1- One Way Ribbed Slab.
2- Tow Way Solid Slab.



.Figure (3-6): Solid Slab.



.Figure (3-7): One Way Ribbed Slab.

- **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.

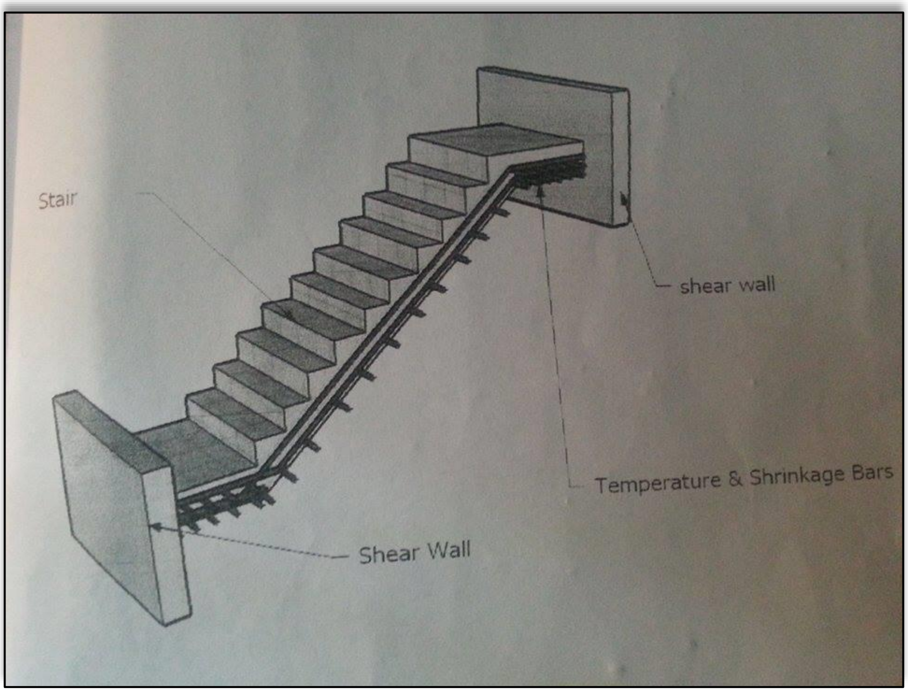


Figure (3-8): The shape of stairs.

- **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).

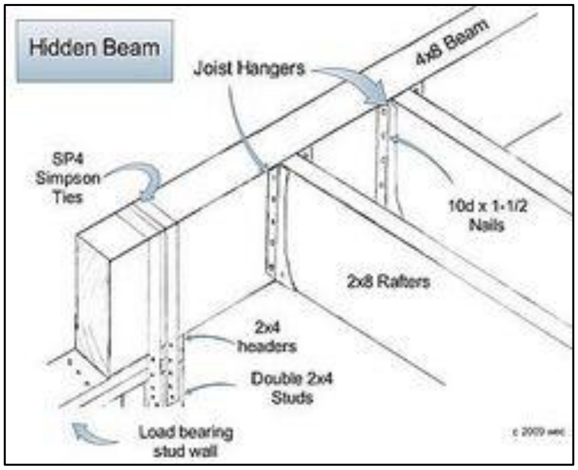


Figure (3-9): Hidden Beam.

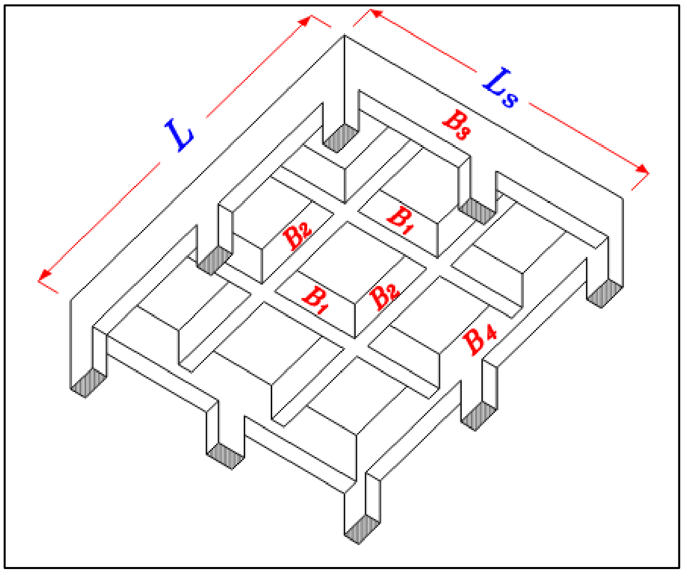


Figure (3-10): Paneled Beam.

- **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.

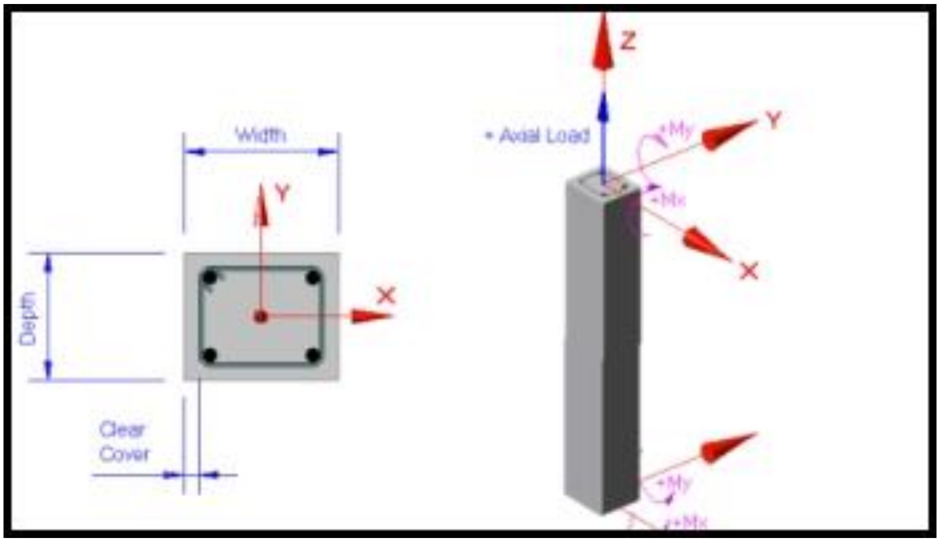


Figure (3-11): Column.

- **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.

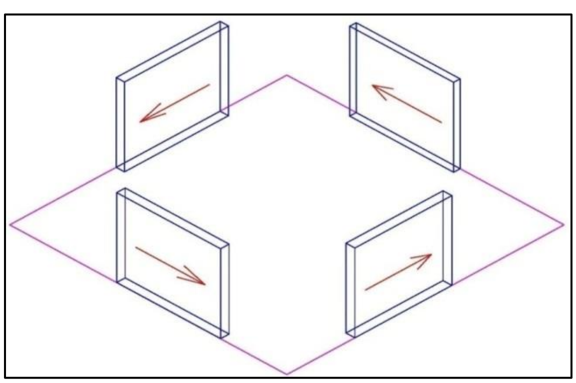


Figure (3-12): Shear Wall.

- **Frames:**

The frame construction is a method of building and designing structures, primarily using steel or steel-reinforced precast concrete. The connections between the columns and the rafters are designed to be moment-resistant.

Figure (3-13): Frame Structure.

Chapter Four

4

Structural Analysis and Design

4-1 Introduction.

4-2 Check of Minimum Thickness of Structural Member.

4-3 Design of Topping.

4-4 Design of One Way Rib Slab.

4-5 Design of beam

4-6 Design of one-way solid

4-7 Design of Coulmn.

4-8 Design of Stairs.

4-9 Design of basement Wall.

4-10 Design shear wall

4-11 Design of isolated footing

4-1 | **Introduction**

Reinforced concrete (RC) is a versatile composite and one of the most widely used materials in modern construction. Concrete is a relatively brittle material that is strong under compression but less so in tension. Plain, unreinforced concrete is unsuitable for many structures as it is relatively poor at with standing stresses induced by vibrations, wind loading and so on.

To increase its overall strength, steel rods, wires, mesh or cables can be embedded in concrete before it sets. This reinforcement, often known as rebar, resists tensile forces. By forming a strong bond together, the two materials are able to resist a variety of applied forces, effectively acting as a single structural element.

Reinforced concrete can be precast or cast-in-place (in situ) concrete, and is used in a wide range of applications such as; slab, wall, beam, column, foundation, and frame construction.

4-1-1 Concrete and its Classifications:

Plain concrete is made by mixing cement, fine aggregate, coarse aggregate, water, and frequently admixtures**,** **Structural concrete can be classified into**:

- Lightweight concrete with a unit weight from about $1350 \text{ to } 1850\ (\frac{kg}{m^3})$ produced from aggregates of expanded shale, clay, slate, and slag.
- Normal-weight concrete with a unit weight from about $1800 \text{ to } 2400\ (\frac{kg}{m^3})$ produced from the most commonly used aggregates— sand, gravel, crushed stone.
- Heavyweight concrete with a unit weight from about $3200 \text{ to } 5600\ (\frac{kg}{m^3})$ produced from such materials such as barite, limonite, magnetite, ilmenite, hematite, iron, and steel punching or shot. It is used for shielding against radiations in nuclear reactor containers and other structures.

4-1-2 Compressive strength of concrete:

The strength of concrete is controlled by the proportioning of cement, coarse and fine aggregates, water, and various admixtures. The most important variable is (w/c) ratio. Concrete strength ($f_c{}'$) – uniaxial compressive strength measured by a compression test of a standard test cylinder ($150\ mm\ diameter\ \ by\ 300\ mm\ high$) on the 28th day–ASTM C31, C39. In many countries, the standard test unit is the cube ($200\ x\ 200\ x\ 200\ mm$).

The concrete strength depends on the size and shape of the test specimen and the manner of testing. For this reason the cylinder ($\emptyset\ 150mm\ by\ 300\ mm\ high$) strength is 80% of the $150\ mm$ cube strength and 83% of the $150\ mm$ cube strength, **figure (4-1)** demonstrate relation between cylinder and cube concrete test.

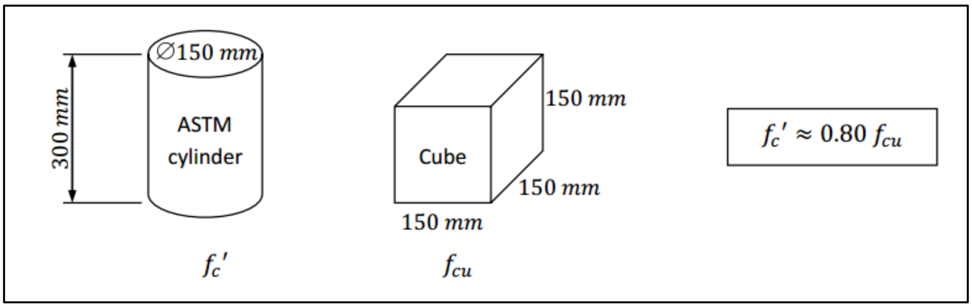


Figure (4-1) relation between cylinder and cube concrete test.

4-1-3 Modulus of Elasticity of concrete:

The modulus of elasticity of concrete varies, unlike that of steel, with strength. A typical stress-strain curve for concrete in compression is shown. The initial modulus (tangent at origin), the tangent modulus (at $0.5\, f_c{}'$), and the secant modulus are noted. Usually the secant modulus at from $25\ to\ 50\%$ of the compressive strength $f_c{}'$ is considered to be the modulus of elasticity. For normal weight concrete, shall be permitted to be taken as $E_c = 4700\sqrt{f_c{}'}$ (Map),

4-1-4 Strength Design method (Ultimate strength method):

In the strength design method, the service loads are increased by factors to obtain the load at which failure is considered to be "imminently". This load is called the factored load or factored service load. The structure or structural element is then proportioned such that the strength is reached when the factored load is acting. The computation of this strength takes into account the nonlinear stress-strain behavior of concrete.

The strength design method may be expressed by the following:

Strength provided ≥ [strength required to carry factored loads]

Where the "strength provided" (such as moment strength) is computed in accordance with the provisions of a building code, and the "strength required" is that obtained by performing a structural analysis using factored loads.

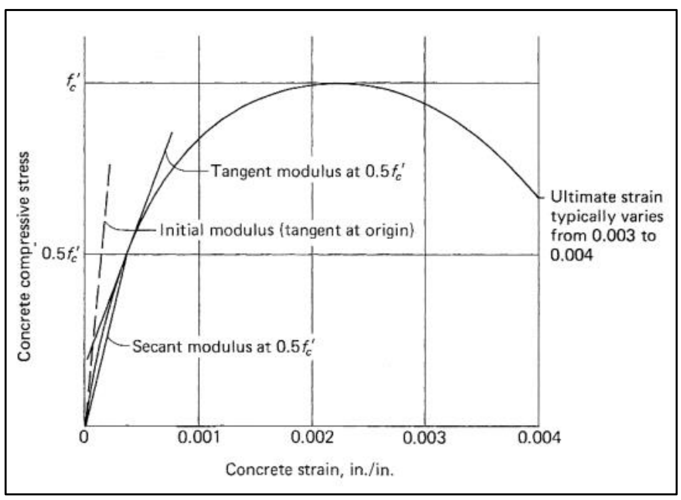


figure (4-2) demonstrate stress-strain concrete

4-1-5 Load Factors U and strength reduction Factor ∅ :

According to (ACI 318-11 9.2.1) the factor U for overload is given:

$U = 1.4D$
$U = 1.2D + 1.6L + 0.5\ (L_r\ or\ S\ or\ R)$
$U = 1.2D + 1.6L + 0.5\ (L_r\ or\ S\ or\ R)$
$U = 1.2D + 1.0W + 1.0\ L + 0.5(L_r\ or\ S\ or\ R)$
$U = 1.2D + 1.0E + 1.0\ L + 0.2\ S$
$U = 0.9D + 1.0W$
$U = 0.9D + 1.0E$

Where:

D : *dead load* .
L : *live load*.
L_r : *roof live load*.
S : *snow load*.
R : *rain load*.
W : *Wind load*.
E : *Earthquake load*.

The factor ∅ (under strength factor) **according to ACI demonstrated in figure (4-3).**

Strength Condition	ϕ Factors
1. Flexure (with or without axial force)	
Tension-controlled sections	0.90
Compression-controlled sections	
Spirally reinforced	0.75
Others	0.65
2. Shear and torsion	0.75
3. Bearing on concrete	0.65
4. Post-tensioned anchorage zones	0.85
5. Struts, ties, nodal zones, and bearing areas in strut-and-tie models	0.75

Figure (4-3) values of understrength factors related to strength condition.

4-1-6 General considerations:

1- **ACI 318-11 Building code will be used in this project.**
2- **UBC-97 code will be used for lateral loads.**
3- **Ultimate strength design method will be used during the analysis and design of this project.**
4- **The compressive strength of concrete for all structural elements is B300 which equals to** $f_c{}' = 24\ Mpa$.
5- **Yield strength of reinforcing rebar's** $f_y = 420\ Mpa$.

4-2 | Check of Minimum Thickness of Structural Member:

It will be determined according to (ACI 318-11) to achieve deflection requirements,

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 and Grade 420 reinforcement. For other conditions, the values shall be modified as follows:
a) For lightweight concrete having equilibrium density, w_c, in the range of 1440 to 1840 kg/m^3, the values shall be multiplied by **(1.65 – 0.0003w_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)**.

Figure (4-4) provided minimum thickness from code

The thickness of slab provided from (ACI 318-11) to achieve requirements of deflection, depends on the Flexural stiff ness of slab, by manual calculation comes about

$\boldsymbol{h_{min} = 32\ cm}$.

So, select **<u>Slab thickness</u>** $\boldsymbol{h = 32cm\ (24\ cm\ Hollow\ Block + 8\ cm\ \ Topping)}$.

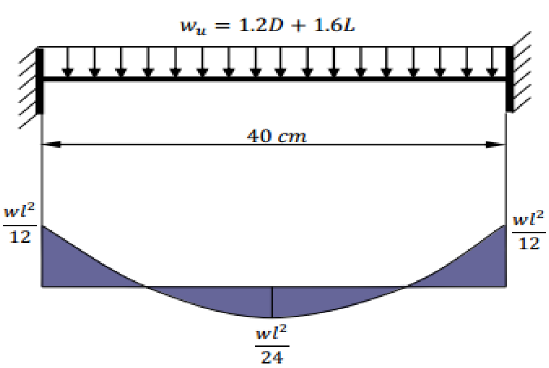
4-3 | Design of Topping:

4-3-1 Load calculations:

- ✓ Topping in One way ribbed slab can be considered as a strip of **1-meter width** and span of hollow block **Load Calculations:** -

Dead Load:

length with both end fixed in the ribs**, Table (4-2)** shows Load calculations on topping.



Live load calculations= $\boldsymbol{4 \times 1 = 4\ \left(\frac{kN}{m}\right)}$

Factored Load: -

W_U = 1.2 ×6.84 + 1.6×4 =14.608 KN/m

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

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

No.	Parts of Rib	Calculation	
1	Tiles	0.03*23*1 = 0.69 KN/m	
2	Mortar	0.03*22*1 = 0.66 KN/m	
3	Coarse Sand	0.07*17*1 = 1.19 KN/m	
4	Topping	0.08*25*1 = 2.0 KN/m	
5	partiton	1*2.3 = 2.3	
		Sum =	6.84KN/m

table (4-1): Dead Load Calculation of Topping

$$S_m = \frac{b.h^2}{6} = \frac{1000.80^2}{6} = 1066666.67\ mm^2$$

$øM_n = 0.55\times1\times\sqrt{24}\times1066666.67\times10^{-6} = 1.2$ KN.m

$M_u = \frac{W_u L^2}{12} = 0.174\text{KN.m}$ (negative moment)

$øM_n >> M_u = 0.174\ \text{KN.m}$

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

$\rho_{shrinkage}$ = 0.0018 ACI 7.12.2.1

$A_s = \rho\times b\times h_{topping}$ =0.0018 ×1000×80 = 144 mm^2/m

Step (s) is the smallest of:

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

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

Take ø 8 @ 200 mm in both direction, S = 200 mm < S_{max} = 240 mm … OK

4.4 Design of One Way Rib Slab (R3)

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

bw ≥ 10cm.…………………………………………ACI (8.13.2)

Select bw=12cm

h ≤ 3.5*bw ……………………………….…ACI(8.13.2)

Select h=35cm<3.5*12= 42 cm

tf ≥ Ln/12≥50mm ………………………………..ACI(8.13.6.1)

Select tf=8cm

❖ **Material :-**

- ⇒ concrete B300 Fc' = 24 MPa
- ⇒ Reinforcement Steel fy = 420 MPa

❖ **Section :-**

- ⇒ B = 520mm
- ⇒ Bw= 120 mm
- ⇒ h= 320 mm
- ⇒ t= 80 mm d=320-20-8-14/2= 285 mm

Statically system and dimensions of rib 3

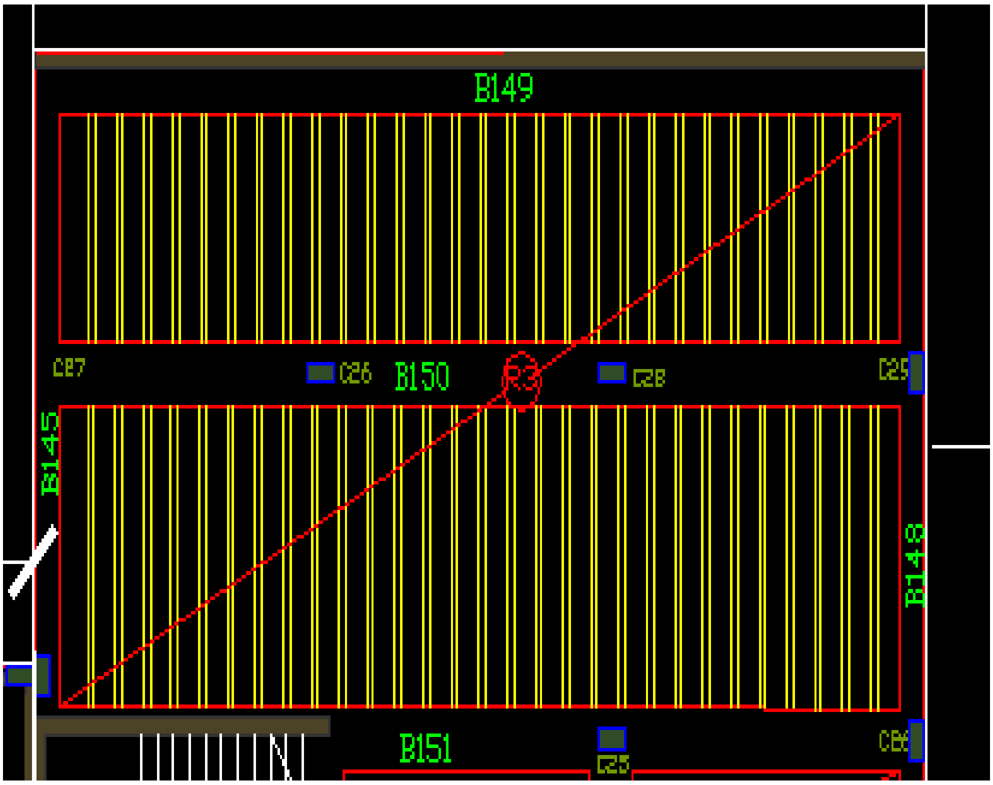


Fig 4.5: One Way Rib Slab (R3).

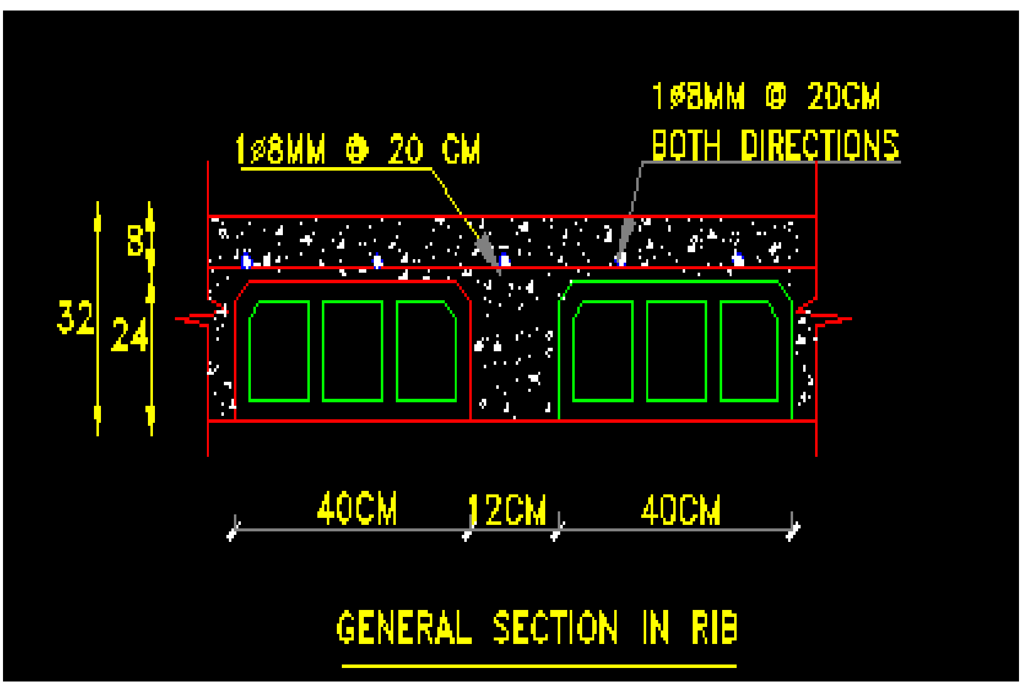


Fig 4.6 : one way rib section of R(3)

✓ **Load Calculation:-**

Dead Load:-

Table (4-2): Dead Load Calculation of Rib (R3).

Type	γ b h	KN/m
Tiles	0.03*0.52*23	0.359
Mortar	0.03*0.52*22	0.343
Sand	0.07*0.52*17	0.619
Topping	0.08*0.52*25	1.04
Hollow block	0.4*0.24*10	0.96
Plaster	0.03*0.52*22	0.343
R.C rib	0.12*0.24*25	0.72
Partition	1*2.3*0.52	1.196
Sum		5.58

Dead Load /rib = 5.58KN/m

Live Load:-

Live load = 4 KN/M^2

Live load /rib = 4 KN/m^2 × 0.52m = 2.08 KN/m.

❖ Effective Flange Width (b_E) :- ACI-318-11 (8.10.2)

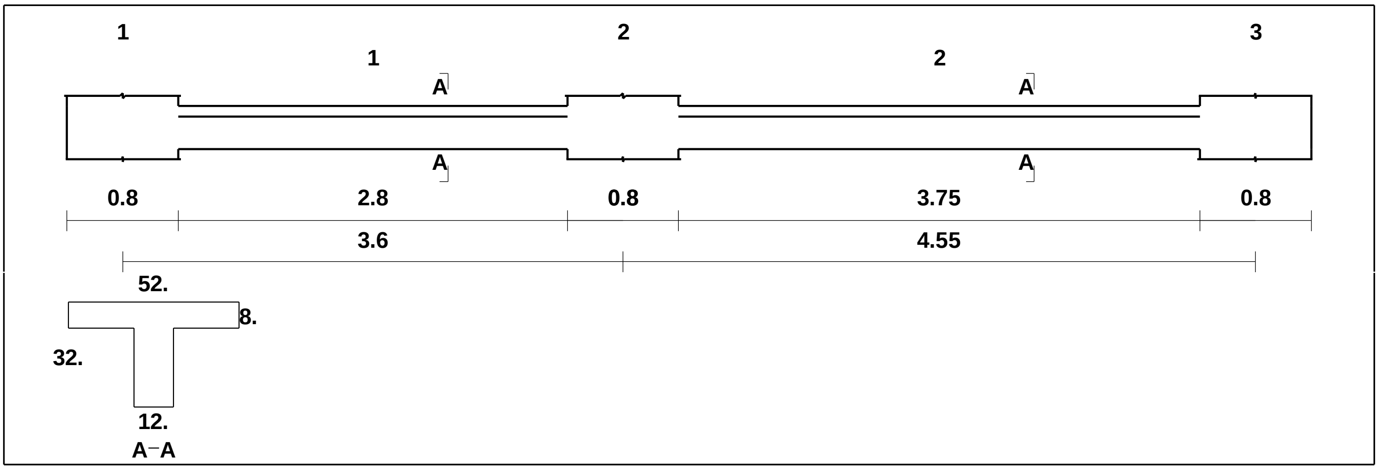
b_E For T- section is the smallest of the following: -

b_E = L / 4 = 7300/ 4 =1825mm

b_E = 16 hf= 16 (80) = 1280 mm

b_E = $b_e \leq$ center to center spacing between adjacent beams = 520 mm. ... **Control**

Geometry Units:meter,cm

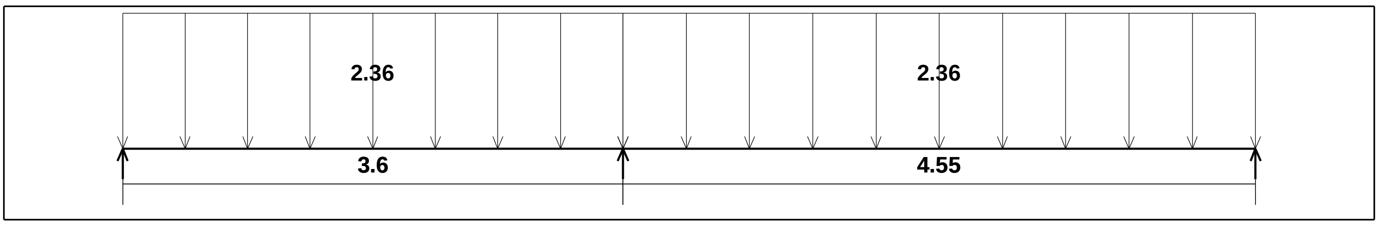


Loading

load group no. 1

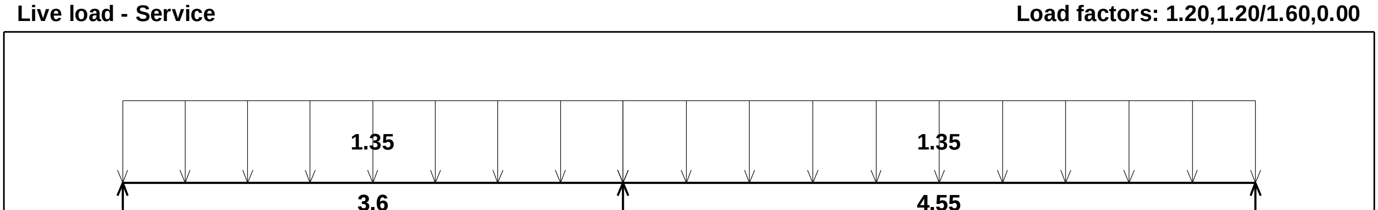
Dead load - Service

Units:kN,meter

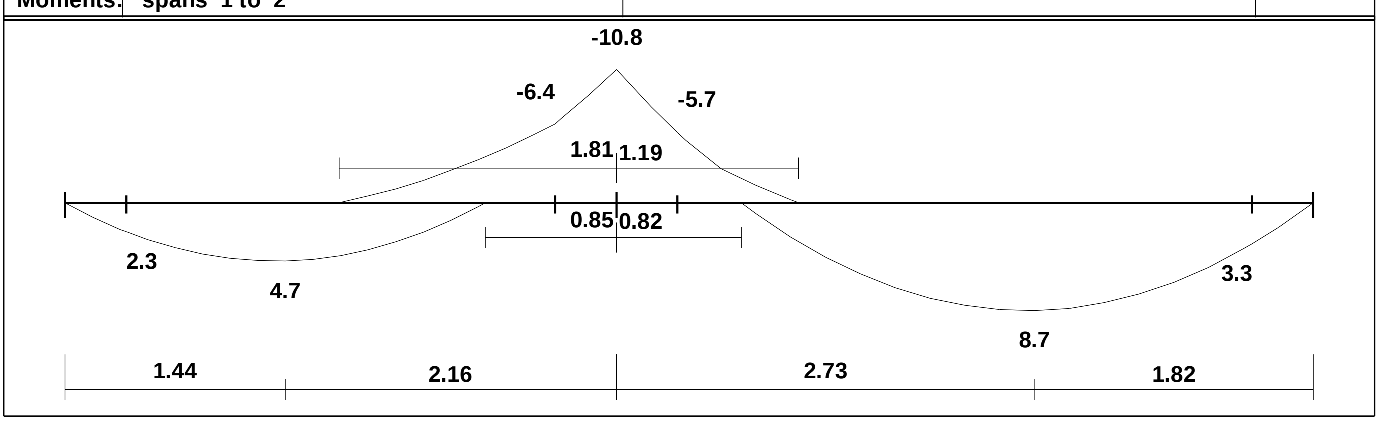


Live load - Service

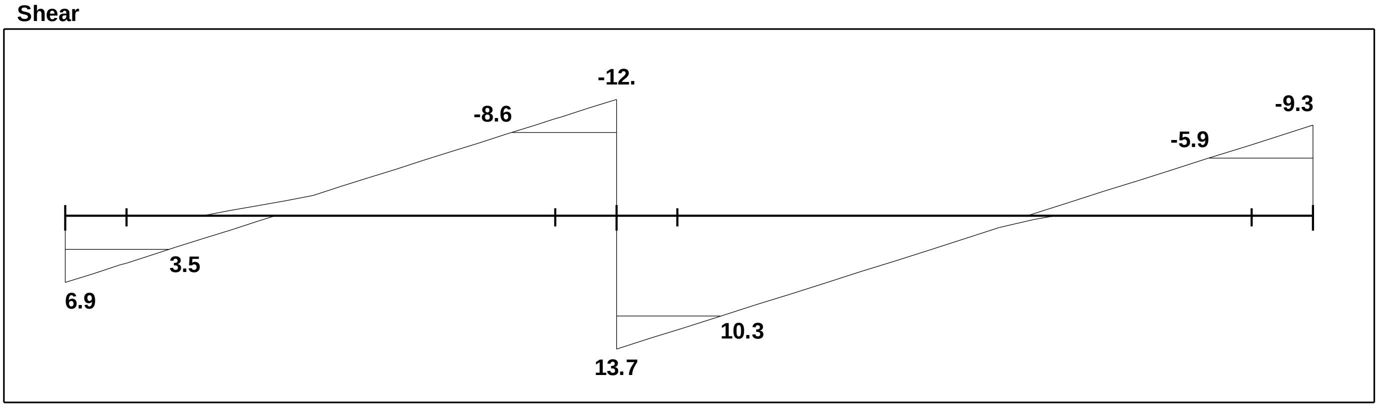
Load factors: 1.20,1.20/1.60,0.00



Moments: spans 1 to 2



Shear



Reactions

Factored			
DeadR	3.4	14.58	5.1
LiveR	3.46	11.12	4.23
Max R	6.86	25.71	9.33
Min R	2.53	19.24	4.76
Service			
DeadR	2.83	12.15	4.25
LiveR	2.16	6.95	2.64
Max R	4.99	19.11	6.89
Min R	2.29	15.06	4.04

Fig 4.7: Shear and Moment Envelope Diagram of (R3).

✓ **Moment Design for (R3): -**

4.4.1 Design of Positive Moment for(R3) :-(Mu=8.7KN.m)

Assume bar diameter ø 12 for main positive reinforcement

d =h- cover - $d_{stirrups} - \frac{d_b}{2} = 320 - 20 - 8 - \frac{12}{2} = 286\ mm$

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

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

$= 0.85 \times 24 \times 520 \times 80 \times \left(286 - \frac{80}{2}\right) \times 10^{-6} = 208.75\ \mathrm{KN.m}$

$M_{nf} \gg \frac{M_u}{\varphi} = \frac{8.7}{0.9} = 9.67$ KN.m , the section will be designed as rectangular section with

b_e =520 mm.

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{8.7 \times 10^6}{0.9 \times 520 \times 286^2} = 0.227\ Mpa$

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

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 0.227}{420}}\right) = 0.00054$

$A_{s,req} = \rho.b.d = 0.00054 \times 520 \times 286 = 80.86\ mm^2$

Check for As min:-

$$A_s \min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) \text{ ACI-318 (10.5.1)}$$

$$A_s \min = \frac{\sqrt{24}}{4(420)}(120)(315) = 110.23mm^2$$

$$A_s \min = \frac{1.4}{(fy)}(bw)(d)$$

$$A_s \min = \frac{1.4}{420}(120)(315) = 126mm^2 \text{ control}$$

$As_{req} = 80.86mm^2 < As_{min} = 126mm^2$ OK

<u>**Use 2 ø 12**</u>

Check for strain:-

$$a = \frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{126\times420}{0.85\times520\times24} = 5mm$$

$$c = \frac{a}{\mathcal{B}_1} = \frac{5}{0.85} = 5.9\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{286-5.9}{5.9}\right) = 0.14 > 0.005 \qquad 0k$$

4.4.2 Design of Negative Moment for (R3): - (Mu= - 10.8 KN.m)

Assume bar diameter ø 12 for main positive reinforcement

$$d = h - cover - d_{stirrups} - \frac{d_b}{2} = 320 - 20 - 8 - \frac{12}{2} = 286\ mm$$

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{10.8\times10^6}{0.9\times520\times286^2} = 0.282Mpa$$

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

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times 20.6\times 0.282}{420}}\right) = 0.00068$$

$A_{s,req} = \rho.b.d = 0.00068\times 520\times 286 = 100.6\ mm^2$

Check for As min:-

$$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)\ \text{ACI-318 (08)}$$

$$As_{min} = \frac{\sqrt{24}}{4(420)}(120)(314) = 109.9 mm2$$

$$As_{min} = \frac{1.4}{(fy)}(bw)(d)$$

$$As_{min} = \frac{1.4}{420}(120)(314) = 125.6 mm^2 \quad \text{….. controls}$$

$As_{req} = 100.6\ mm^2 < As_{min} = 125.6\ mm^2$ OK

Use 2 ø 12 , $A_{s,provided} = 404.48mm^2 > A_{s,required} = 395.3mm^2$… Ok

Check for strain: -

$$a = \frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{125.6\times 420}{0.85\times 520\times 24} = 5mm$$

$$c = \frac{a}{B_1} = \frac{5}{0.85} = 5.9\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{286-5.9}{5.9}\right) = 0.14 > 0.005 \qquad Ok$$

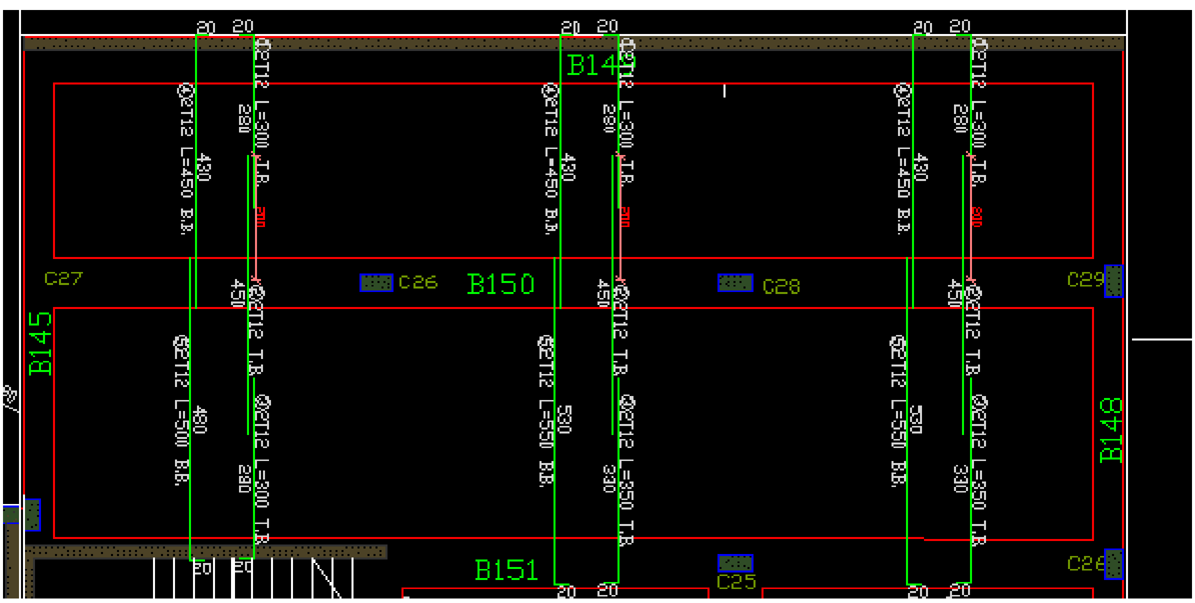


Fig 4.8 : توزيع حديد العصب (R(3))

- ✓ **4.4.3 Shear Design for (R3):-**

V_u at distance d from support=26.8KN

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

$V_c = \frac{1.1}{6} \lambda \sqrt{f_c'} b_w d = \frac{1.1}{6}\sqrt{24} \times 120 \times 286 \times 10^{-3} = 33.9\ KN$

ø V_c =0.75×33.9. =25.46 KN

Check for items:-

1- Vu ≤ Φ Vc/2

26.8>12.73 (not ok)

2- Φ Vc/2 ≤ Vu ≤ Φ Vc

15.9375<26.8>25.46 (not ok)

3- Φ Vc ≤ Vu ≤ Φ Vc + Φ Vsmin

Φ Vsmin $\geq 0.75\ (\frac{1}{3})$ * bw * d = 0 .75*$(\frac{1}{3})$*120*0.315= 9.45 KN. (control)

$\geq$ 0.75 $(\frac{\sqrt{24}}{16}$ * bw * d = 0.75 * $\frac{\sqrt{24}}{16}$*0.315*120= 8.6 KN

ΦVsmin = 9.45KN.

Φ Vc =25.46≤Vu= 26.8< (Φ Vc + Φ Vsmin) =35.9Ok

Soitem3 satisfy.

S = d/2 = 315/2 = 157.5mm (control)

S = 600 mm

Take Av = 2 Φ 8 = 2 * 50 = 100 mm^2

Av/ s = Vs/fy * d

2*50/ s = 12.6*1000/(315*420) → s = 1050 mm

Take S = 150 mm … Use 2 Φ8 @15 cm c/c.

4.5 Design of Beam (B (150)):

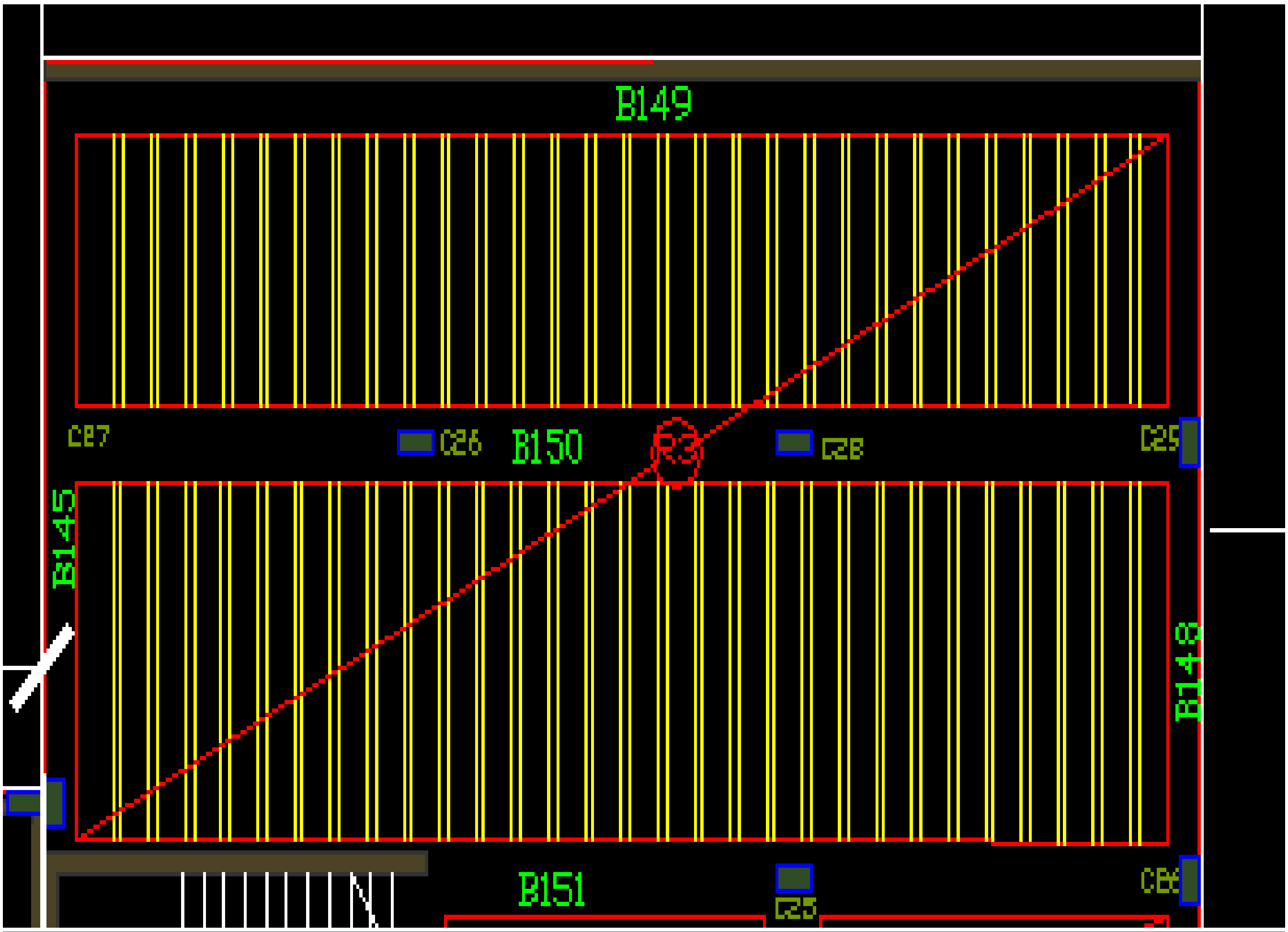


Fig 4.9:beam (B(150)):

H=570/21=27.2 cm

H=32 cm

Load calculation:

From Reaction –from (R3):

Dead load = 12.15/0.52=23.36 KN/m

Live load =6.95/0.52=13.36 KN/m

Weight of beam =0.8*25*0.32=6.4kn/m

L.L=0.5*4=2.08

Weight of wall (25thick,4high)

❖ Material :-

⇒ concrete B300 Fc' = 24 MPa

⇒ Reinforcement Steel fy = 420 MPa

❖ Section:-

⇒ Bw=800 mm

⇒ h= 320 mm

⇒ tf = 350 mm

⇒ d=320-40-10-18/2=262 m

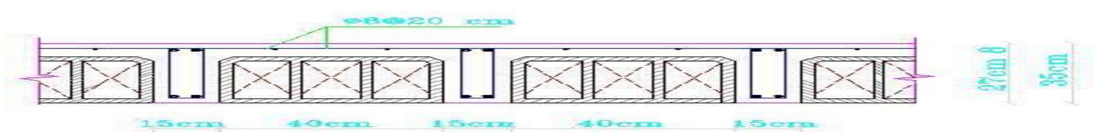
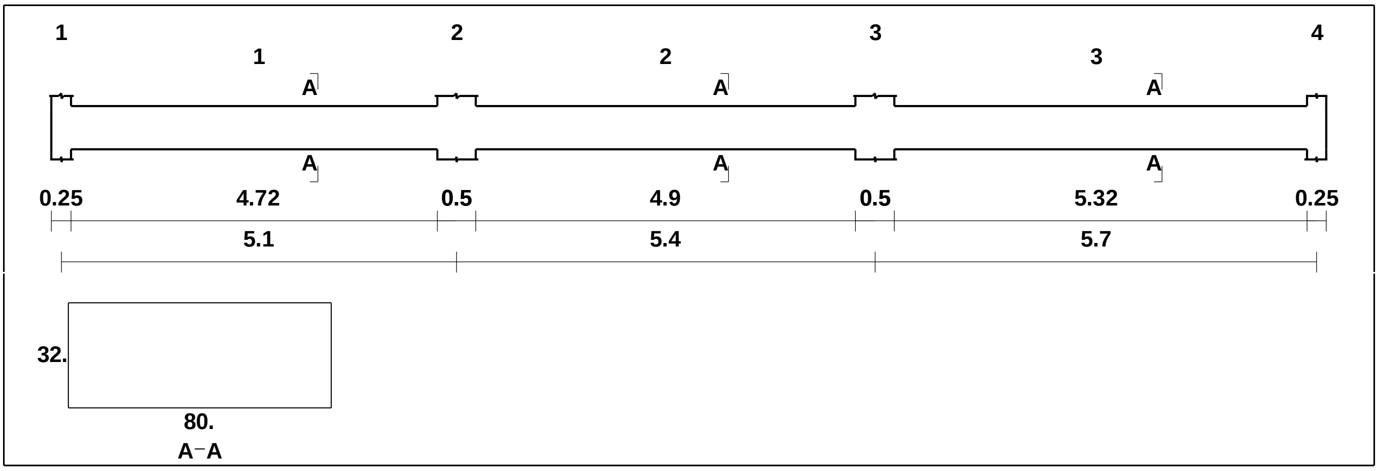


Fig (4.10) Statically System and Loads Distribution of Beam B (150)

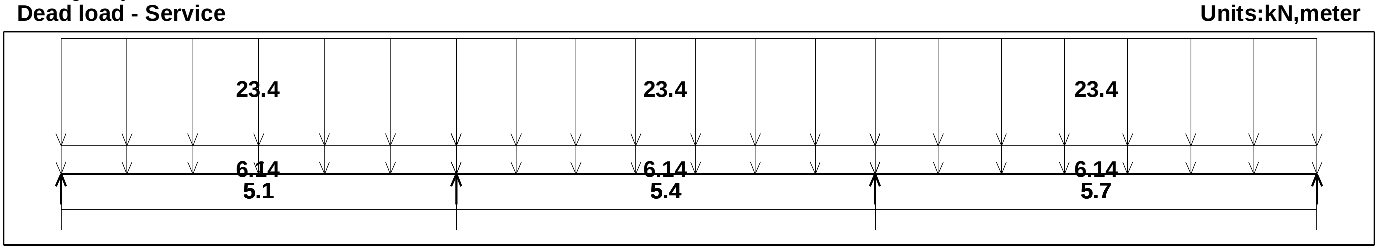
✓ Moment Design for (B(150)):-

✓ G e o m e t r y   Units:meter,cm

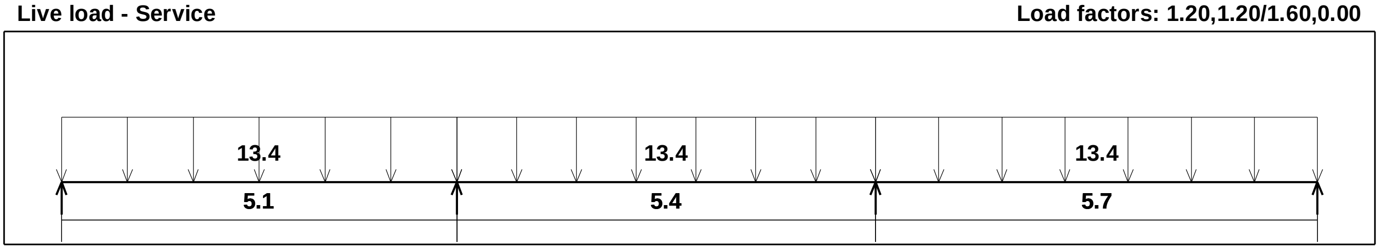


L o a d i n g

load group no. 1
Dead load - Service
Units:kN,meter



Live load - Service
Load factors: 1.20,1.20/1.60,0.00

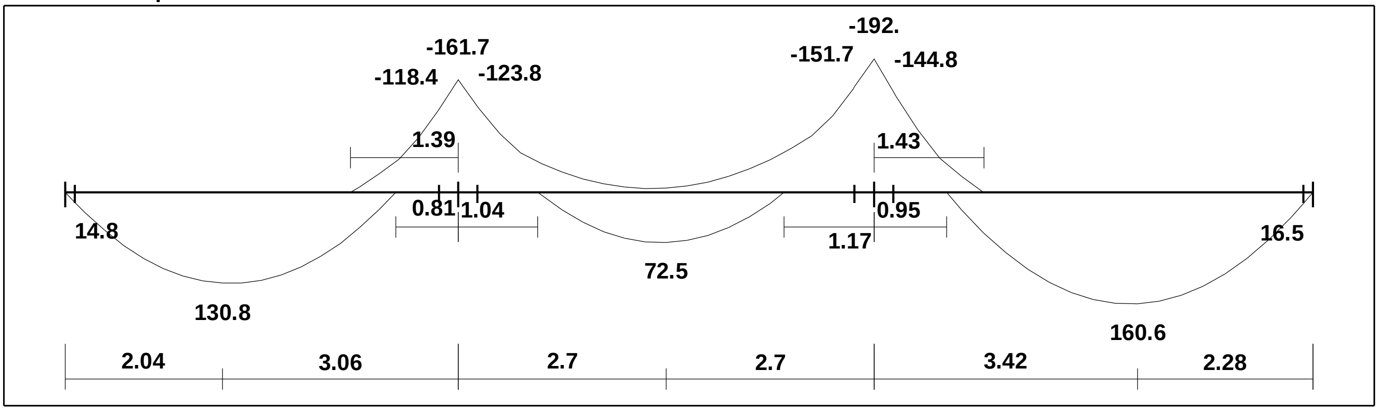


Loads (kN,meter)

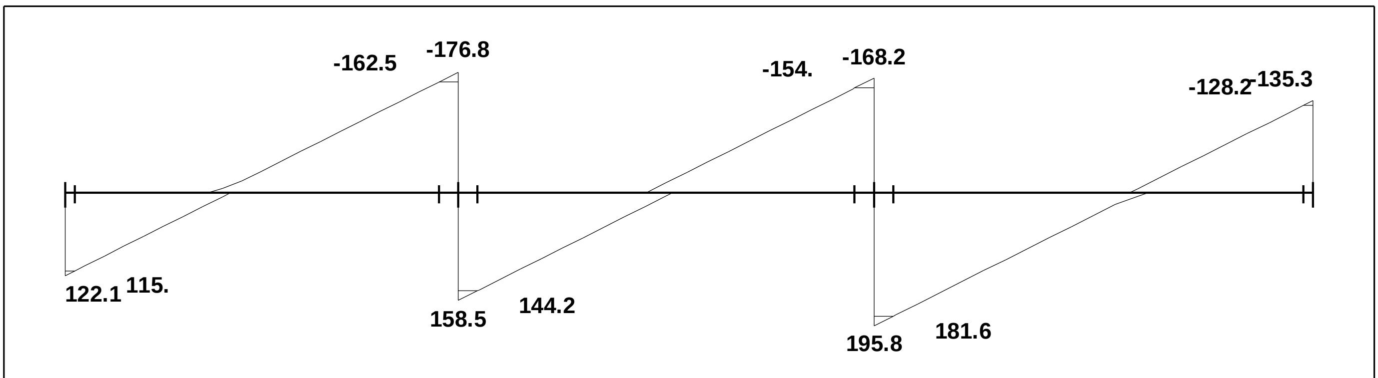
1				2				3			
Self.Wt.			6.14	Self.Wt.			6.14	Self.Wt.			6.14
Uni D	23.40	L	13.40	Uni D	23.40	L	13.40	Uni D	23.40	L	13.40

Moment/Shear Envelope (Factored)   Units:kN,meter

Moments: spans 1 to 3



Shear



Reactions

Factored

DeadR	72.15	200.48	220.69	81.01
LiveR	50.	134.75	143.32	54.28
Max R	122.15	335.23	364.01	135.29
Min R	65.79	251.65	273.58	75.73
Service				
DeadR	60.13	167.07	183.91	67.51
LiveR	31.25	84.22	89.57	33.92
Max R	91.37	251.28	273.49	101.43
Min R	56.15	199.05	216.97	64.21

Fig 4.11: Shear and Moment Envelope Diagram of B(150)

✓ **Span (L=5.1 m):**

1- Flexural Design of Positive Moment for (B (150)) :-(Mu=130.8KN.m)

Determine of $Mn_{,max}$

use ø 18

d =320 – 40 -10 – 18\2 = 262 mm

$$c = \frac{3}{7} d = \frac{3}{7} * 262 = 112.3\ mm$$

$$a = \mathcal{B}.c = 112.3 * 0.85 = 95.44 mm$$

$Mn_{max} = 0.85 f_c' ab(d - \frac{a}{2}) = 0.85*24*95.44*800*(262-95.44/2) *10^{-6} = 333.8 KN.m$

$\emptyset\ Mn_{max}$ = 0.82* 333.8 = 273.7 KN.m>130.8 KN/m

Design as singly reinforcement:

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{130.8 \times 10^6}{0.9 \times 800 \times 262^2} = 2.65 Mpa$$

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

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \times 20.6 \times 2.65}{420}}\right) = 0.0068$$

$A_{s,req} = \rho.b.d = 0.0068 \times 800 \times 262 = 1419.8\ mm^2$

Check for As min:-

$$As\ min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) \text{ ACI-318 (10.5.1)}$$

$$As\ min = \frac{\sqrt{24}}{4(420)}(800)(262) = 611.2 mm^2$$

$$As\ min = \frac{1.4}{(fy)}(bw)(d)$$

$$As\ min = \frac{1.4}{420}(800)(262) = 698.7 mm^2 \text{ control}$$

$As_{req} = 1419.8\ mm^2 > As_{min} = 698.7\ mm^2$ … use As As_{req}

<u>Use 8 ø 18, $A_{s,provided} = 1600 mm^2 > A_{s,required} = 1419.8\ mm^2$… Ok</u>

S = $\frac{800-2*40-20-(8*18)}{7} = 79.4\ mm > d_b = 18 > 25\ mm \qquad OK$

Check for strain: -

a =$\frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{1419.8\times420}{0.85\times800\times24} = 36.5mm$

c= $\frac{a}{\mathcal{B}_1} = \frac{36.5}{0.85} = 42.94mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{262-42.94}{42.94}\right) = 0.015 > 0.005 \qquad 0k$$

2-Flexural Design of Negative Moment for (B(150) :-(Mu=161.7 KN.m)

- ✓ **<u>Moment Design for (B 150)</u>:-**

Determine of $Mn_{,max}$

use ø 18

d =320 – 40 -10 – 18\2 = 262 mm

$c = \frac{3}{7}d = \frac{3}{7} * 262 = 112.3\ mm$

a $= \mathcal{B}.c = 112.3 * 0.85 = 95.44mm$

Mn_{max} = $0.85f_c'ab(d - \frac{a}{2})$ = 0.85*24*95.44*800*(262-95.44/2) *10^{-6}= 333.8KN.m

Ø Mn_{max} = 0.82* 333.8 = 273.7 KN.m>161.7 KN/m

Design as singly reinforcement:

R_n= $\frac{M_u}{\emptyset b d^2} = \frac{161.7\times10^6}{0.9\times800\times262^2} = 3.27Mpa$

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

ρ= $\frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times3.27}{420}}\right) = 0.0085$

$A_{s,req}$ = ρ.b.d = 0.0085×800×262 = 1790.23 mm^2

Check for As min:-

$A_{s\ min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ ACI-318 (10.5.1)

$$A_{s\,min} = \frac{\sqrt{24}}{4(420)}(800)(262) = 611.2mm^2$$

$$A_{s\,min} = \frac{1.4}{(fy)}(bw)(d)$$

$$A_{s\,min} = \frac{1.4}{420}(800)(262) = 698.7mm^2 \text{ control}$$

As_{req} = 1790.23 mm² > As_{min}= 698.7 mm² … use As As_{req}

Use 9 ø 18, $A_{s,provided}$ = 1800mm²> $A_{s,required}$ = 1790.23 mm²… Ok

$$S = \frac{800-2*40-20-(9*18)}{8} = 67.25mm > d_b = 18 > 25\ mm \qquad OK$$

$$a = \frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{1790.23\times420}{0.85\times800\times24} = 46.1mm$$

$$c = \frac{a}{\mathcal{B}_1} = \frac{46.1}{0.85} = 54.23mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{262-54.23}{54.23}\right) = 0.0115 > 0.005 \qquad 0k$$

Span (L=5.4 m):

1-Flexural Design of positive Moment for (B (150) :-(Mu=72.5 KN.m)

- ✓ **Moment Design for (B (150)): -**

Determine of $Mn_{,max}$

use ø 14

d =320 – 40 -10 – 14\2 = 263 mm

$$c = \frac{3}{7}d = \frac{3}{7} * 263 = 112.3\ mm$$

$$a = \mathcal{B}.c = 112.3 * 0.85 = 95.44mm$$

Mn_{max} = $0.85f_c'ab(d - \frac{a}{2})$ = 0.85*24*95.44*800*(262-95.44/2) *10^{-6}= 333.8KN.

Ø Mn_{max} = 0.82* 333.8 = 273.7 KN.m>72.5 KN/m

Design as singly reinforcement:

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{72.5\times10^6}{0.9\times800\times263^2} = 1.45Mpa$

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

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times1.45}{420}}\right) = 0.0036$

$A_{s,req} = \rho.b.d = 0.0036\times800\times263 = 757.4 \ mm^2$

Check for As min:-

$As\ min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ ACI-318 (10.5.1)

$As\ min = \frac{\sqrt{24}}{4(420)}(800)(262) = 611.2mm^2$

$As\ min = \frac{1.4}{(fy)}(bw)(d)$

$As\ min = \frac{1.4}{420}(800)(262) = 698.7mm^2$ control

$As_{req} = 757.4\ mm^2 > As_{min} = 698.7\ mm^2$ … use As As_{req}

Use 8 ø 14, $A_{s,provided} = 960mm^2 > A_{s,required} = 757.4\ mm^2$… Ok

$S = \frac{800-2*40-20-(8*14)}{7} = 84\ mm > d_b = 18 > 25\ mm \qquad OK$

$a = \frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{757.4\times420}{0.85\times800\times24} = 19.5mm$

$c = \frac{a}{B_1} = \frac{46.1}{0.85} = 22.9mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{263-22.9}{22.9}\right) = 0.0314 > 0.005 \qquad 0k$$

2- Flexural Design of negative Moment for (B (150) :-(Mu=192 KN.m)

Determine of $Mn_{,max}$

use ø 18

d =320 – 40 -10 – 18\2 = 262 mm

$c = \frac{3}{7}d = \frac{3}{7} * 262 = 112.3\ mm$

$a = \mathcal{B}.c = 112.3 * 0.85 = 95.44mm$

$Mn_{max} = 0.85f_c'ab(d - \frac{a}{2}) = 0.85*24*95.44*800*(262-95.44/2)*10^{-6} = 333.8KN.$

$\emptyset Mn_{max} = 0.82* 333.8 = 273.7$ KN.m>192 KN/m

Design as singly reinforcement:

$R_n = \frac{M_u}{\emptyset bd^2} = \frac{192\times10^6}{0.9\times800\times262^2} = 3.88Mpa$

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

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2\times20.6\times3.88}{420}}\right) = 0.00939$

$A_{s,req} = \rho.b.d = 0.00939\times800\times263 = 1975.65\ mm^2$

$As_{req} = 1975.65\ mm^2 > As_{min} = 698.7\ mm^2$ … use As As_{req}

Use 10 ø 18, $A_{s,provided} = 2000mm^2 > A_{s,required} = 1975.65\ mm^2$… Ok

$S = \frac{800-2*40-20-(10*18)}{9} = 57.8\ mm > d_b = 18 > 25\ mm \quad OK$

$a = \frac{A_s.f_y}{0.85b\ f_c'} = \frac{1975.65\times420}{0.85\times800\times24} = 50.8mm$

$c = \frac{a}{\mathcal{B}_1} = \frac{50.8}{0.85} = 59.8mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{262-59.8}{59.8}\right) = 0.01 > 0.005 \qquad 0k$$

- **Span (L=5.7m):**

✓ **Moment Design for (G.B(18):-**

1- Flexural Design of Positive Moment for (B (150)) :-(Mu=160.6KN.m)

Determine of $Mn_{,max}$

use ø 18

d =320 – 40 -10 – 18\2 = 262 mm

$c = \frac{3}{7}d = \frac{3}{7} * 262 = 112.3\ mm$

$a = \mathcal{B}.c = 112.3 * 0.85 = 95.44mm$

$Mn_{max} = 0.85f_c'ab(d - \frac{a}{2}) = 0.85*24*95.44*800*(262-95.44/2)*10^{-6} = 333.8KN.m$

$\emptyset$ Mn_{max} = 0.82* 333.8 = 273.7 KN.m>160.6 KN/m

Design as singly reinforcement:

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{160.6\times10^6}{0.9\times800\times262^2} = 3.27 Mpa$$

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

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times3.27}{420}}\right) = 0.0085$$

$A_{s,req}$ = ρ.b.d = 0.0085×800×262 = 1790.23 mm^2

Check for As min:-

$$As\ min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) \text{ ACI-318 (10.5.1)}$$

$$As\ min = \frac{\sqrt{24}}{4(420)}(800)(262) = 611.2mm^2$$

$$As\ min = \frac{1.4}{(fy)}(bw)(d)$$

$$As\ min = \frac{1.4}{420}(800)(262) = 698.7mm^2 \text{ control}$$

As_{req} = 1790.23 mm^2 > As_{min}= 698.7 mm^2 … use As As_{req}

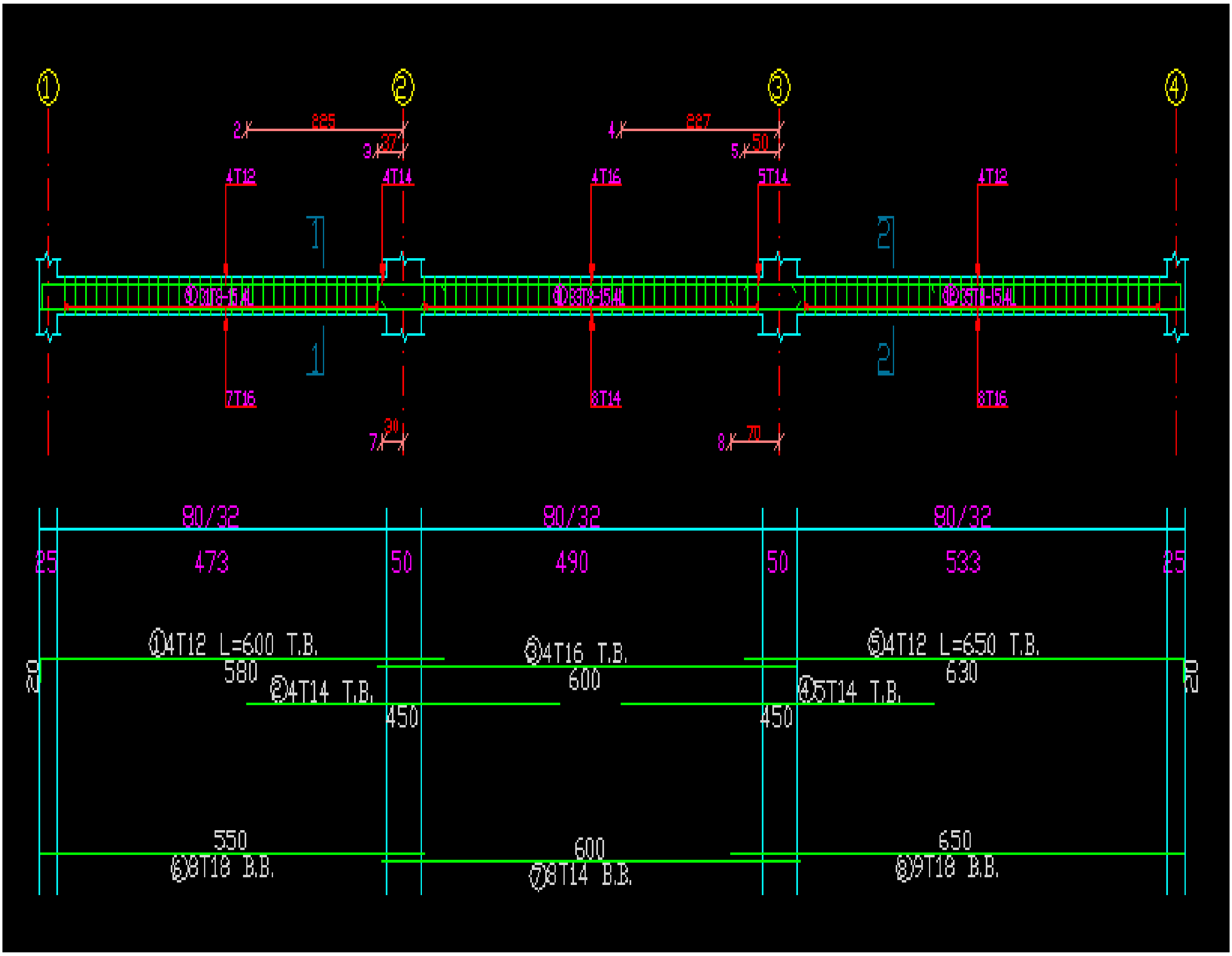
Use 9 ø 18, As,provided = 1800mm2> As,required = 1790.23 mm2… Ok

$$S = \frac{800-2*40-20-(9*18)}{8} = 67.25mm > d_b = 18 > 25\ mm \quad OK$$

$$a = \frac{A_{s}.f_y}{0.85b\ f_c'} = \frac{1790.23\times420}{0.85\times800\times24} = 46.1mm$$

$$c = \frac{a}{\beta_1} = \frac{46.1}{0.85} = 54.23mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{262-54.23}{54.23}\right) = 0.0115 > 0.005 \quad 0k$$



1
2
3
4
825
827
37
50
4T12
4T14
4T16
5T14
4T12
7T16
8T14
8T16
30
70
80/32
80/32
80/32
25
473
50
490
50
533
25
①4T12 L=600 T.B.
580
③4T16 T.B.
600
⑤4T12 L=650 T.B.
630
②4T14 T.B.
④5T14 T.B.
450
450
20
20
550
⑥8T18 B.B.
600
⑦8T14 B.B.
650
⑧9T18 B.B.

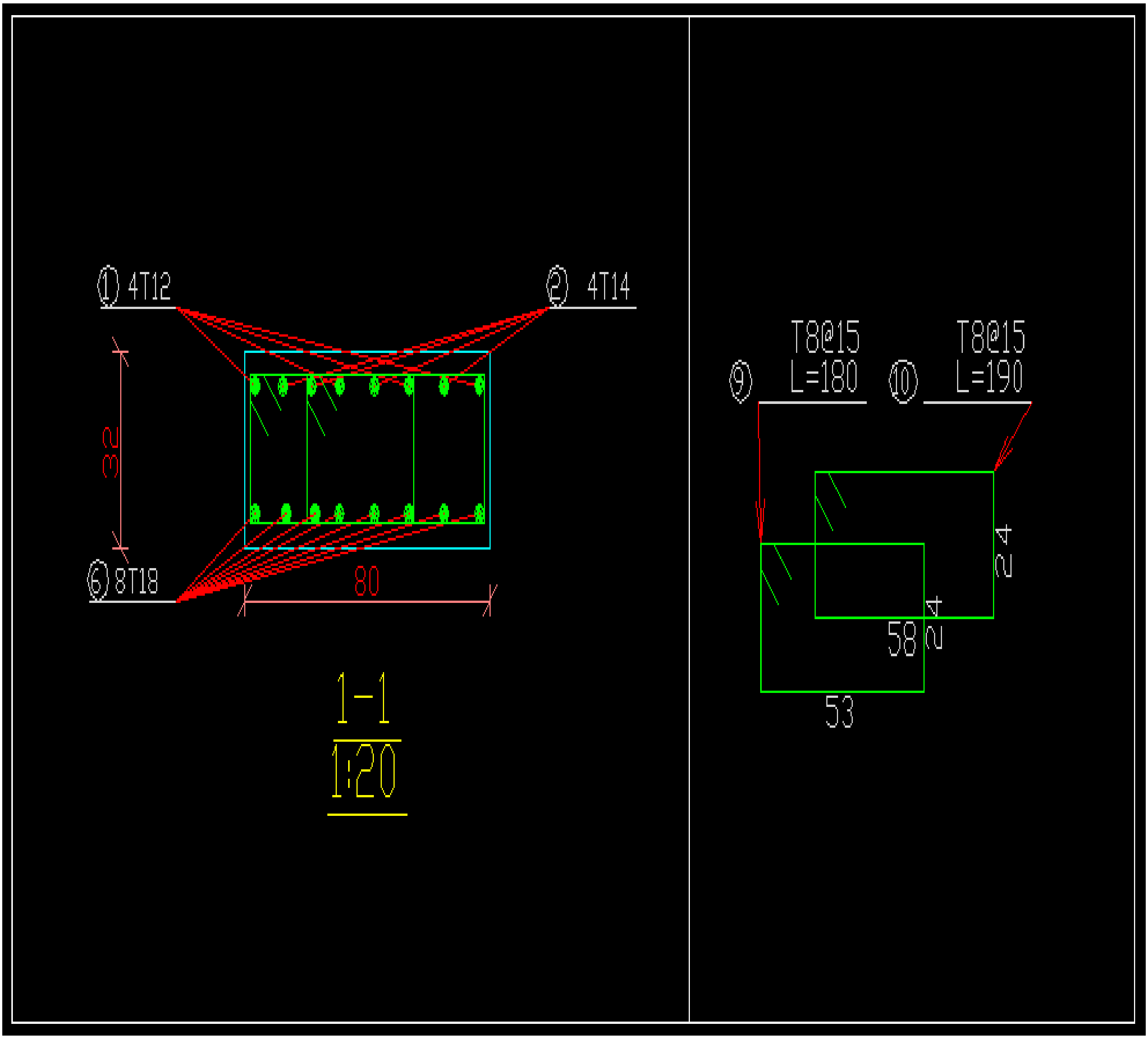
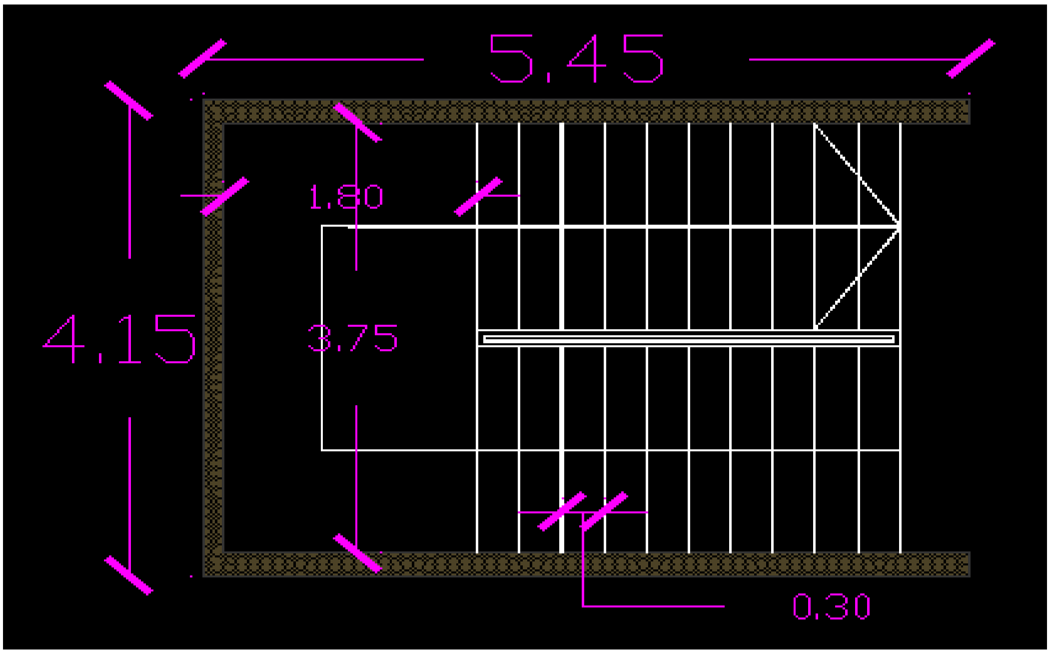


Fig 4.12 : توزيع حديد الجسر (B(150))

4-6 DESIGN OF ONE WAY SOLID SLAB:



❖ **Fig 4.13 : Plan of solid slab**

❖ **Material:**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel fy = 420 N/mm^2

✓ **Slab Thickness Calculation:**

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

Min H (deflection requirement):

H = L/24 = 550/24 =22.9

For One way solid slab, will use thickness of slab 25 cm.

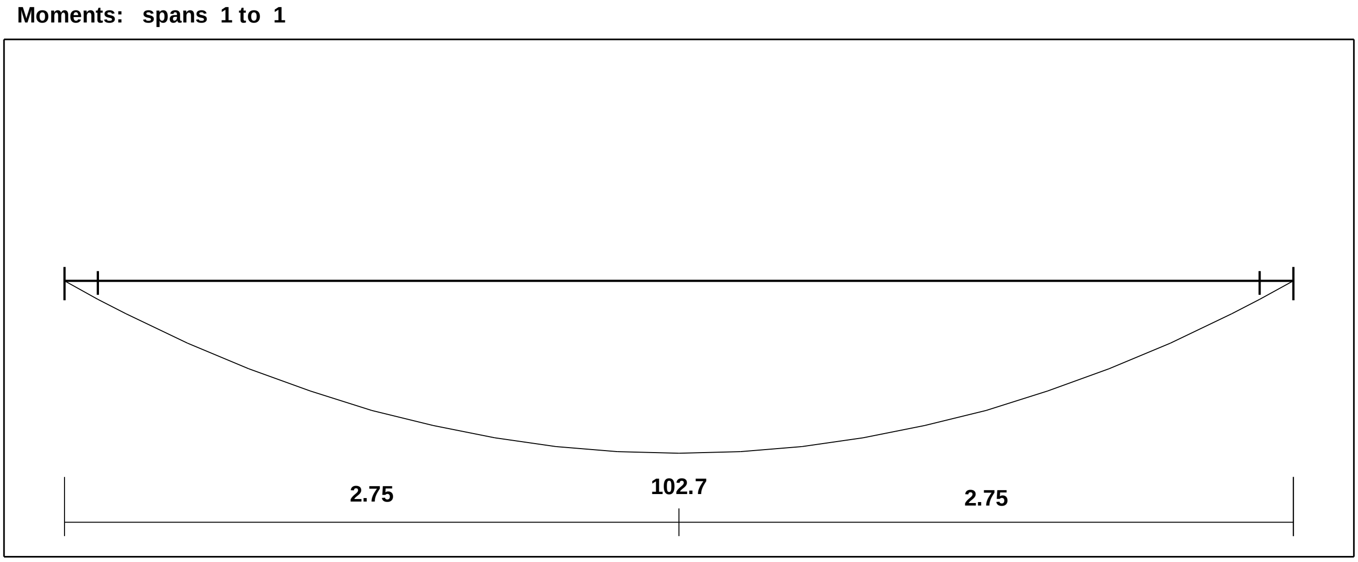
Dead Load For Solid slab:

No.	Parts of Rib	Calculation	
1	Tiles	0.03*23*1 = 0.69 KN/m	
2	Mortar	0.02*22*1 = 0.44 KN/m	
3	Coarse Sand	0.07*17*1 = 1.19 KN/m	
4	plaster	0.02*22*1 = 0.44 KN/m	
5	RC. Solid slab	0.25*25 = 6.25KN/m^2	
6	Partitions	2.3*1 = 2.3 KN/m	
		Sum =	11.31KN/m

Table (4.3): Dead Load Calculation of solid slab.

Live Load For Solid slab = 4*1 =5Kn/m

✓ System of Landing:



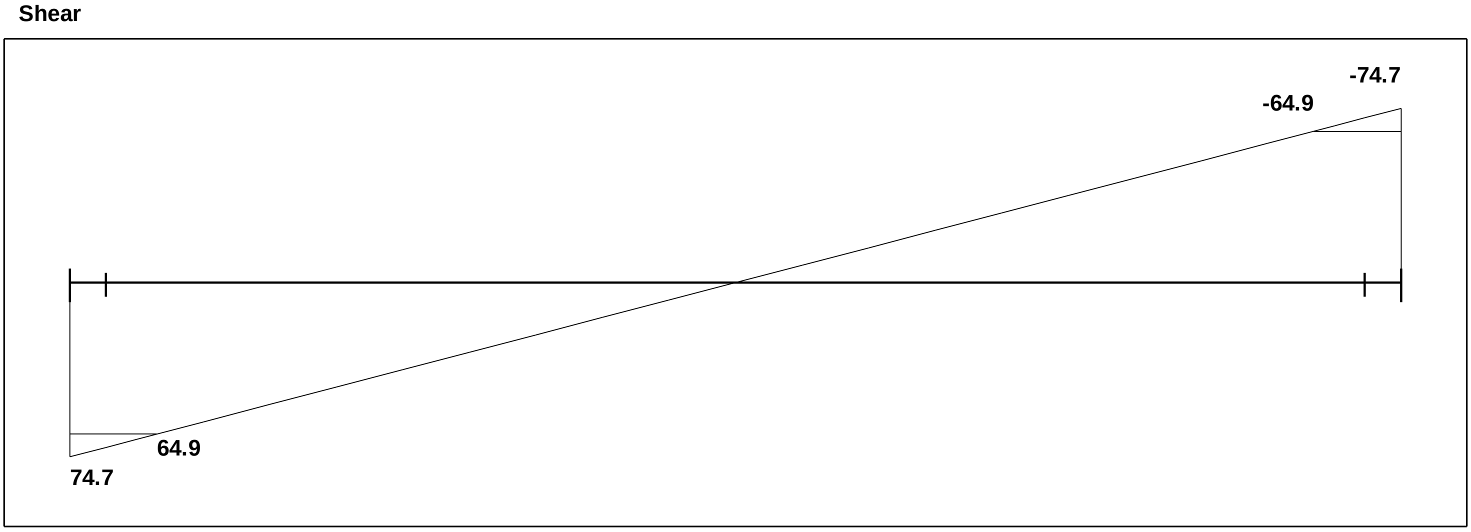


Fig 4.14 : Shear and moment envelop diagram of solid slab

✓ Design of Shear:

(Vu=74.7 Kn)

Assume bar diameter ø 12 for main reinforcement

d =h- cover $- \frac{d_b}{2} = 350 - 20 - \frac{12}{2} = 324\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d == \frac{1}{6}\sqrt{24} * 1000 * 324 = 264.5$ KN

$\Phi * V_c = 0.75 * 264.5 = 198.4$ KN> Vu = 74.7 KN…... **Thickness Is Enough (No need for shear)**

1- Design of Bending Moment (Mu=102.7 KN/m) :-

d =h- cover $-\frac{d_b}{2} = 350 - 20 - \frac{12}{2} = 324\ mm$

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{102.7\times10^6}{0.9\times1000\times324^2} = 1.09\ Mpa$

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

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times1.09}{420}}\right) = 0.00266$

$A_{s,req} = \rho.b.d = 0.00266\times1000\times324 = 862.2\ mm^2$

Check for $A_{s,\ min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*1000*324 = 944.8\ mm^2$

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*1000*324 = 1080\ mm^2$ **Controls**

Use ø14 @125 mm , $A_{s,provided}$= 1230 mm^2>$A_{s,required}$= 1080 mm^2… Ok

Number of bars required in 1m strip = 1230/154 = 8 bars

Then use 8 Ø 14@ 12.5 mm

Check for strain:

$a = \frac{A_s.f_y}{0.85 b\ f_c'} = \frac{1230\times420}{0.85\times1000\times24} = 25.32\ mm$

$c = \frac{a}{B_1} = \frac{25.32}{0.85} = 29.8\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{324\ -29.8}{29.8}\right) = 0.0296 > 0.005 \qquad \mathbf{0}\boldsymbol{k}$$

✓ lateral or Secondary Reinforcement of Solid slab :

$A_{s,req}$= $A_{s,min}$ =0.0018*1000*250 = 450 mm2

Use ø10 @ 175 mm $A_{s,\ provided}$= 451 mm2 > $A_{s,required}$= 450 mm2… Ok

✓ Top Reinforcement :

$A_{s,min}$ =0.0018*1000*250 = 450 mm2
Use mesh ø10 @ 175 mm .

4-7 | Design of Column (11), Ground Floor.

4-7-1 Design Data:

The following table and figures gives the design parameters of column (11) Ground Floor:

$Dead\ load\ (service)$	$574\ kN$
$Live\ load\ (service)$	$151\ kN$
$Length$	$3.75\ m$
k	$1\ (Braced)$
D	$55\ cm$
f_y	$420\ Mpa$
f'_c	$24\ Mpa$
Concrete cover	$40\ mm$
$Bar\ size$	$\emptyset 20\ mm$
$Type\ of\ load$	$Concentrically\ Loaded$

Table (4-4): Design Data of column (11).

4-8-2 Factored Loads:

$P_u = 1.2\ D + 1.6L$

$P_u = 1.2\ (574) + 1.6(151) = 931\ kN$

4-8-3 Selecting Column Dimenssion:

Assum Ast = 0.015Ag

$\emptyset Pn, max = \emptyset 0.85[0.85.fc(Ag - Ast) + Ast.Fy]$

$931 * 10^3$ = **0.75*0.85[0.85*24*(Ag-0.015Ag)+(0.015Ag*420)]**

$Ag = 55282.3\ mm^2$

Ag=A.B

55282.3 = **A.B**

take A=40cm

take b=600mm2

Ag= **A.B** =240000mm^2

- ✓ **Check Slenderness Parameter:-**

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \le 40$$

Lu: Actual unsupported (Unbraced) length.

K: effective length factor.

R: radius of gyration = $\sqrt{\frac{I}{A}}$ ≈0.3 h ……………….For rectangular section

Lu = 3.75 m
M1/M2 =1
K=1 for braced frame.

- **about X-axis**

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \le 40$$

$$\frac{1 \times 3.75}{0.4 \times 0.4} = 23.4 > 22$$

Column Is Long About X-axis

- **about Y-axis**

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \le 40$$

$$\frac{1 \times 3.75}{0.3 \times 0.6} = 20.8 < 22$$

Column Is short About Y-axis

✓ Minimum Eccentricity:-

$$\min\ e = 15 + 0.03 \times h = 15 + 0.03 \times 400 = 27mm = 0.027m$$
$$e = 0.027m$$

✓ Magnification Factor:-

$$\delta_{ns} = \frac{Cm}{1 - \frac{Pu}{0.75P_c}} \geq 1.0 and \leq 1.4$$

$$Cm = 0.6 + 0.4\left(\frac{M1}{M2}\right) \geq 0.4$$
$$Cm = 0.6 + 0.4 * 1 = 1 \geq 0.4$$

$$P_{cr} = \frac{\pi^2 EI}{(KLu)^2}$$

$$EI = 0.4\frac{E_c I_g}{1 + \beta_d}$$
$$E_c = 4700\sqrt{fc'} = 4700 \times \sqrt{24} = 23025.2Mpa$$
$$\beta_d = \frac{1.2DL}{Pu} = \frac{1.2 * (574)}{931} = 0.74 < 1$$
$$I_g = \frac{b \times h^3}{12} = \frac{600 \times 400^3}{12} = 3.2 * 10^9\,mm^4$$
$$EI = \frac{0.4 \times 23025.2 \times 3.2}{1 + 0.74} = 16938KN.m^2$$

$$P_C = \frac{\pi^2 * 16938}{(1 * 3.75)^2} = 7401.8KN$$

$$\delta_{ns} = \frac{1}{1 - \frac{931}{0.75 * 7401.8}} = 1.2 \geq 1.0 and \leq 1.4$$

✓ **Interaction Diagram:-**

$$e_{\min} \times \delta_{ns} = 0.027 \times 1.2 = 0.0324m$$
$$\frac{e}{h} = \frac{0.0324}{0.4} = 0.081$$
$$\gamma = \frac{400 - 2*40 - 2*10 - 25}{400} = 0.6875$$
$$\frac{\phi * Pn}{Ag} = \frac{Pu}{Ag} = \frac{931*10^3}{600*400} * 0.145 = 0.56KSI$$
$$For \gamma = 0.6 and \frac{e}{h} = 0.112 and \frac{\phi * Pn}{Ag} = 0.56$$
$$\rho = 0.017$$
$$As = 0.017*300*600 = 3060mm4$$

USE 14 ϕ 20 With As > As required

✓ **Design of the Stirrups:-**

The spacing of ties shall not exceed the smallest of :-

$$spacing \le 16 \times d_b = 16 \times 2.5 = 40\ cm$$
$$spacing \le 48 \times d_s = 48 \times 1.0 = 48\ cm$$
$$spacing \le least \dim = 30\ cm$$

$Use \phi 10 @ 20\ cm$

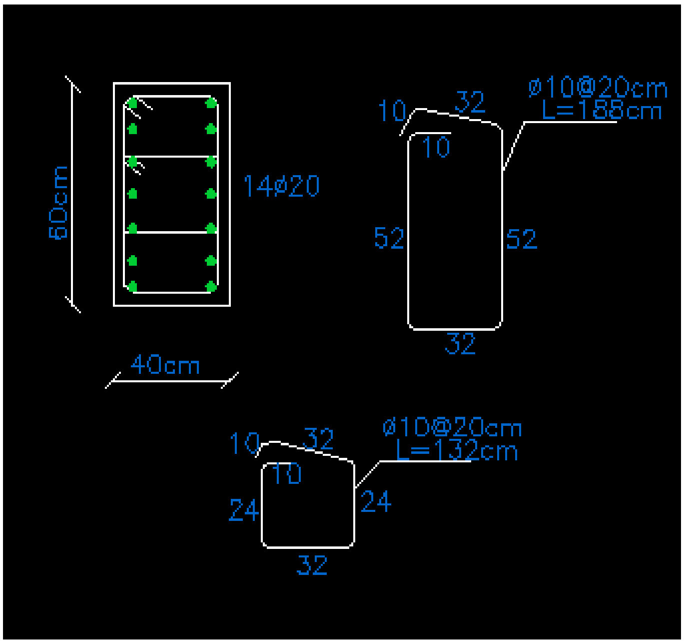


Figure (4-15): Details of column.

4-8 | **Design of Staircase:**

live load of $L_l = 4 \left(\frac{kN}{m^2}\right)$, *assuming rise of* **155 mm** , *and run of* **300 mm** , $f_{c'} = 24\ Mpa$, $f_y = 420\ Mpa$.

4-8-1 plan and materials of stair:

The following figure demonstrate the plan of stair that we consider to design it figure (4-29) which is carries a uniform

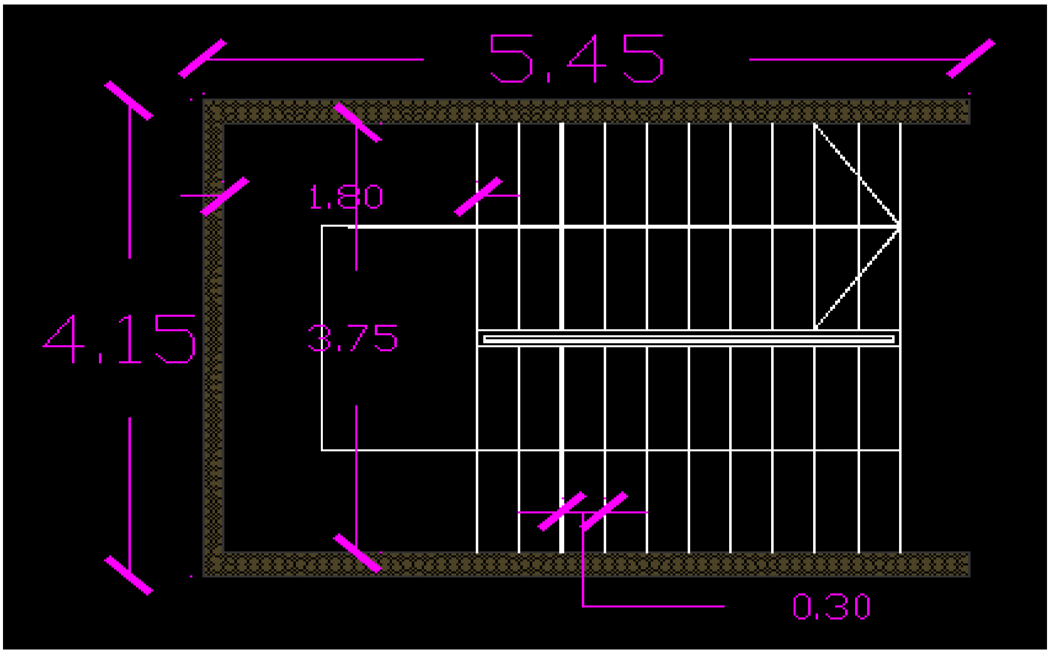


Figure (4-16): Stair Plan and structural system.

4-8-2 Structural system and minimum thickness:

1. **The structural system of this stair was taken as a simply supported (one-way solid slab) since that the flight of stair will be supported at the ends of upper and lower landings.**
2. **Minimum Slab thickness for deflection is (for simply supported one-way solid slab) is** $h_{min} = \frac{L}{20} = \frac{545}{20} = 27.25\ cm$ **, but in this case presented here where the slab ends are cast white the supporting beams and additional negative reinforcement is provided , minimum thickness can be assumed to be** $h_{min} = \frac{L}{28} = \frac{545}{28} = 19.46\ cm.$

$$Take\ h_{min} = 25\ cm$$

4-8-3 Loads and Reactions calculations:

The applied live loads are based on the plan area (horizontal projection), while the dead load is based on the sloped length. To transform the dead load into horizontal projection the figure below explains how figure (4-30).

$$\theta = tan^{-1}\left(\frac{rise}{run}\right) = tan^{-1}\left(\frac{155}{300}\right) = 27.32^{\circ}$$

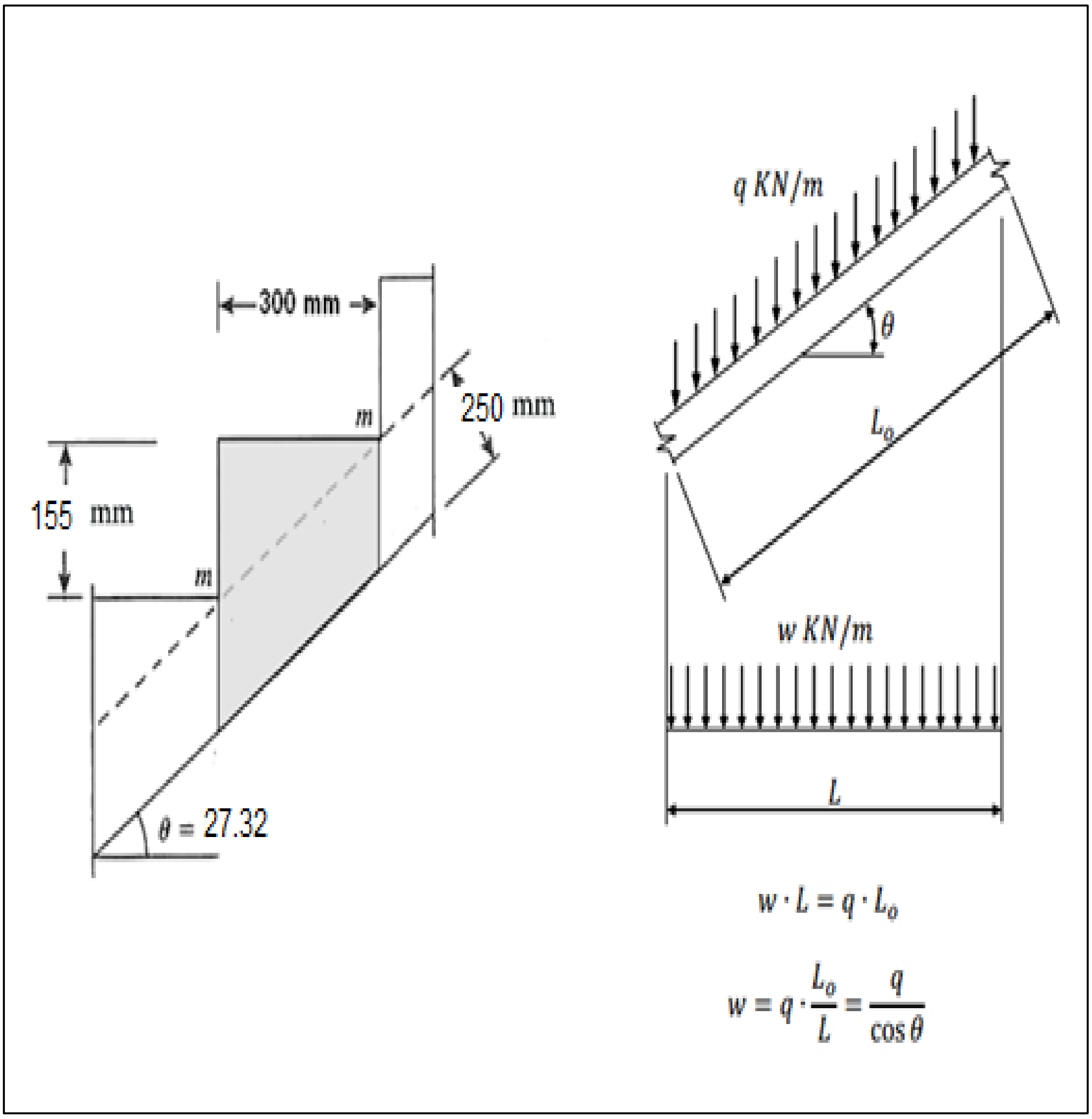


Figure (4-17): Transformation of dead load into horizontal projection.

- **Flight Dead Load computation:**

Table (4-6) shows Dead Load calculations on Flight of stair:

Dead Load Form	Unit weight γ $(\frac{kN}{m^3})$	w $(\frac{kN}{m})$
Tiles	**27**	$27 \times \left(\frac{0.155+0.35}{0.3}\right) \times 0.03 \times 1 = 1.36$
Mortar	**22**	$22 \times \left(\frac{0.155+0.3}{0.3}\right) \times 0.03 \times 1 = 1.001$
Stair steps	**25**	$\frac{25}{0.3} \times \left(\frac{0.155 \times 0.3}{2}\right) \times 1 = 1.93$
Reinforced concrete (solid slab)	**25**	$\frac{25 \times 0.25 \times 1}{cos\,27.32} = 7.04$
plaster	**22**	$\frac{22 \times 0.03 \times 1}{cos\,27.32} = 0.75$
$\sum$ *Tota Dead loads kN/m*		12.1

Table (4-5) Dead Load calculations on flight.

- **Landing Dead Load computation:**

Dead Load Form	Unit weight γ $(\frac{kN}{m^3})$	$\gamma \times \delta \times 1$ $(\frac{kN}{m})$
Tiles	**23**	$23 \times 0.03 \times 1 = 0.69$
Mortar	**22**	$22 \times 0.03 \times 1 = 0.66$
Reinforced concrete (solid slab)	**25**	$25 \times 0.25 \times 1 = 6.25$
plaster	**22**	$22 \times 0.03 \times 1 = 0.66$
$\sum$ *Tota Dead loads kN/m*		8.26

Table (4-6) shows Dead Load calculations on landing of stair

- **Live Load:** $L_l = 4\ \left(\frac{kN}{m^2}\right)$.
- **Total Factored Load:** $w = 1.2\ D_L + 1.6\ L_l$

For flight : $w = 1.2\ (12.1) + 1.6(4) = 20.92\ \left(\frac{kN}{m}\right)$.

For Landing : $w = 1.2\ (8.26) + 1.6(4) = 16.3\left(\frac{kN}{m}\right)$.

16.3/2=8.15

4-8-4 Design of flight 1:

The support reaction of flighting is:

$\frac{[(8.15*3.9)+(20.92*3.48)]}{2} = 52.3\ \left(\frac{kN}{m}\right)$. **as shown in figure (4-31).**

Shear and moment calculations:

- **Check for shear strength:**

  Assume bar diameter $\emptyset 14\ for\ main\ rinforcemnt.$

  $$d = h - cover - \frac{d_b}{2} = 250 - 20 - \frac{14}{2} = 223\ mm$$

  Assume wall width $30\ cm$

  $$V_u = 52.3 - 8.15 \times (0.155 + 0.223) = 49.2\ kN$$

  $$V_c = \frac{1}{6}\sqrt{f_{c'}}b_w d = \frac{1}{6} \times \sqrt{24} \times 1000 \times 223 = 182.7\ kN\ ..for\ 1\ m\ strip$$

$$\phi = 0.75 - for\ shear$$

$$\phi V_c = 0.75\ \times 182.7 = 136.55\ kN\ ..\ for\ 1m\ strip$$

$$V_{u,max} = 49.2\ kN\ < \frac{1}{2}\phi V_c = 68.27kN$$

$\therefore$ *The thickness of the slab is adequate enough*

- **Calculation of maximum moment and steel reinforcement:**

$$M_{u,max} = 52.3 \times \left(2.4 + \frac{3.48}{2}\right) - 8.15 \cdot (2.4) \cdot \left(2.4/2 + \frac{3.48}{2}\right) - 20.92(1.74)\left(\frac{1.74}{2}\right)$$
$$= 127.34kN.m \text{ / m}$$

$\textit{assume bar diameter } \emptyset 14 \textit{ for main rinforcemnt with } , d = 223 \ mm$

$$R_n = \frac{M_u}{\emptyset bd} = \frac{127.34 \times 10^6}{0.9 \times 1000 \times 223^2} = 2.8Mpa \ , m = \frac{f_y}{0.85 \, f_c'} = \frac{420}{0.85 \times (24)} = 20.6$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2R_n m}{f_y}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 \cdot 2.8 \cdot 20.6}{420}}\right) = 0.0072$$

$$A_s = \rho bd = 0.0072 \times 1000 \times 223 = 1605.6 \, mm^2$$

$$A_{s,min} = 0.0018bh = 0.0018 \times 1000 \times 250 = 450mm^2$$

$$A_s = 1605.6mm^2 > A_{s,min} = 450 \, mm^2 \ , use \ \emptyset 14$$

$$Use \ 11\emptyset 14@15 \ cm \ \ with \ \ A_{s,prov} = 1693.3 \, mm^2 > A_s = 1605.6 \, mm^2 for \ (1m) \ strip$$

Check maximum step for main reinforcement (the smallest of):

1. $3h = 3 \times 250 = 750 \ mm$
2. $450mm.$
3. $S = 380 \left(\frac{280}{f_s}\right) - 2.5C_c = 380\left(\frac{280}{\frac{2}{3} \times 420}\right) - 2.5 \times 20 = 330mm$

$$S_{max} = 300 \left(\frac{280}{f_s}\right) = 300\left(\frac{280}{\frac{2}{3} \times 420}\right) = 300mm \ - controled$$

$$S = 15 \ cm \ < \ S_{max} = 30 \ cm - OK$$

- **Temperature and shrinkage reinforcement:**

$$A_s(temperature \ and \ shrinkagr) = 0.0018bh = 0.0018(1000)(250) = 450 \, mm^2$$

$$Use \ \ 7\emptyset 10@10cm \ \ with \ \ A_{s,prov} = 553 \, mm^2 > A_s = 450 \, mm^2 for \ (1m) \ strip$$

Check maximum step for temperature and shrinkage (the smallest of):

1. $5h = 5 \times 250 = 1250\ mm$
2. $450mm.\ \ - controled$

$S = 10\ cm\ < \ S_{max} = 45\ cm - OK$

4-8-5 Design of flight 2:

The support reaction of flighting is:

$\frac{[(8.15*3.9)+(20.92*3.48)]}{2} = 52.3\ \left(\frac{kN}{m}\right)$. as shown in figure (4-32).

Shear and moment calculations:

- **Check for shear strength:**

  Assume bar diameter $\emptyset 14\ for\ main\ rinforcemnt.$

  $d = h - cover - \frac{d_b}{2} = 250 - 20 - \frac{14}{2} = 223\ mm$

  Assume wall width 30 cm

  $V_u = 52.3 - 8.15 \times (0.155 + 0.223) = 49.2\ \ kN$

  $V_c = \frac{1}{6}\sqrt{f_{c'}}b_w d = \frac{1}{6} \times \sqrt{24} \times 1000 \times 223 = 182.7\ kN\ ..for\ 1\ m\ strip$

$\phi = 0.75 - for\ shear$

$\phi V_c = 0.75\ \times 182.7 = 136.55\ kN\ ..\ \ for\ 1m\ strip$

$V_{u,max} = 49.2\ kN\ \ < \frac{1}{2}\phi V_c = 68.27kN$

$\therefore The\ thickness\ of\ the\ slab\ is\ adequate\ enough$

- **Calculation of maximum moment and steel reinforcement:**

  $M_{u,max} = 127.34\ kN.m$ / m

$assume\ bar\ diameter\ \emptyset 14\ for\ main\ rinforcemnt\ with\ \ ,d = 223\ mm$

$R_n = \frac{M_u}{\emptyset bd} = \frac{127.34 \times 10^6}{0.9 \times 1000 \times 223^2} = 2.8\ Mpa\ \ ,m = \frac{f_y}{0.85\ f_c{}'} = \frac{420}{0.85 \times (24)} = 20.6$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2R_n m}{f_y}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\cdot 2.8\cdot 20.6}{420}}\right) = 0.0072$$

$$A_s = \rho bd = 0.0072 \times 1000 \times 223 = 1605.6 \ mm^2$$

$$A_{s,min} = 0.0018bh = 0.0018 \times 1000 \times 250 = 450mm^2$$

$$A_s = 1605.6 \ mm^2 > A_{s,min} = 450 \ mm^2 \quad , use \ \emptyset 14$$

$$Use \ 11\emptyset 14@15 \ cm \ \ with \ \ A_{s,prov} = 1693.3 \ mm^2 > A_s = 1605.6 \ \ mm^2 for \ (1m) \ strip$$

Check maximum step for main reinforcement (the smallest of):

4. $3h = 3 \times 250 = 750 \ mm$
5. $450mm.$
6. $S = 380\left(\frac{280}{f_s}\right) - 2.5C_c = 380\left(\frac{280}{\frac{2}{3}\times 420}\right) - 2.5 \times 20 = 330mm$

$$S_{max} = 300\left(\frac{280}{f_s}\right) = 300\left(\frac{280}{\frac{2}{3}\times 420}\right) = 300mm \ - controled$$

$$S = 15 \ cm < \ S_{max} = 30 \ cm - OK$$

- **Temperature and shrinkage reinforcement:**

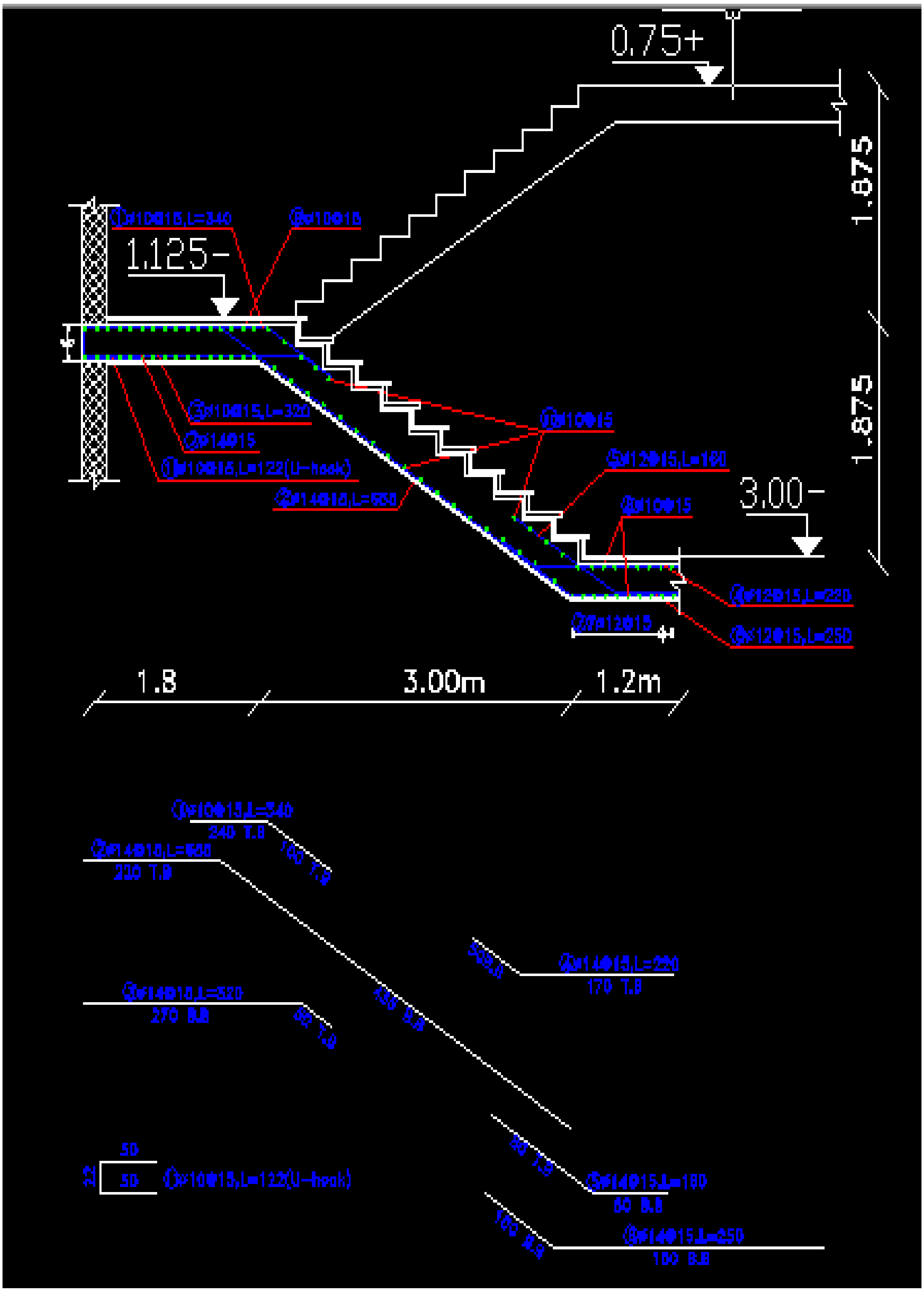
$$A_s(temperature \ and \ shrinkagr) = 0.0018bh = 0.0018(1000)(250) = 450 \ mm^2$$

$$Use \ \ 7\emptyset 10@10 \ cm \ \ with \ \ A_{s,prov} = 553 \ mm^2 > A_s = 450 \ mm^2 for \ (1m) \ strip$$

Check maximum step for temperature and shrinkage (the smallest of):

3. $5h = 5 \times 250 = 1250 \ mm$
4. $450mm. \ - controled$

$$S = 10 \ cm \ < \ S_{max} = 45 \ cm - OK$$



<u>Figure (4-18)</u> : Details of stairs

4.9 DESIGN of BASEMENT WALL .

<u>Note : Column Load On theBasement wall not included , we designed these columns</u>

- **Material :-**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

✓ **Load Calculations :-**

Soil density = 18 Kg/cm3 , L.L = 5 KN/m^2

angle of friction in soil ø= 35°

the wall is Pinned-Pinned system

the backfill is dry (No Water)

K_0 = 1- sin ø = 0.426

* Load on basement wall.

For 1m length of wall:

* Weight of backfill:

q1 = $K_0 \times$ desnsity $\times$ h $\times$ b = 0.426 * 18 * 3.75 $\times$ 1 = 32.59 KN/m **(Due to soil)**

q1(fact) = 1.6*32.59 = 52.144KN/m

* Load from live load:

q2 = $K_0 \times$ L.L= 0.426 * 5 = 2.13 KN/m **(Due to L.L)**

q2(fact) = 1.6*2.13 = 3.41 KN/m

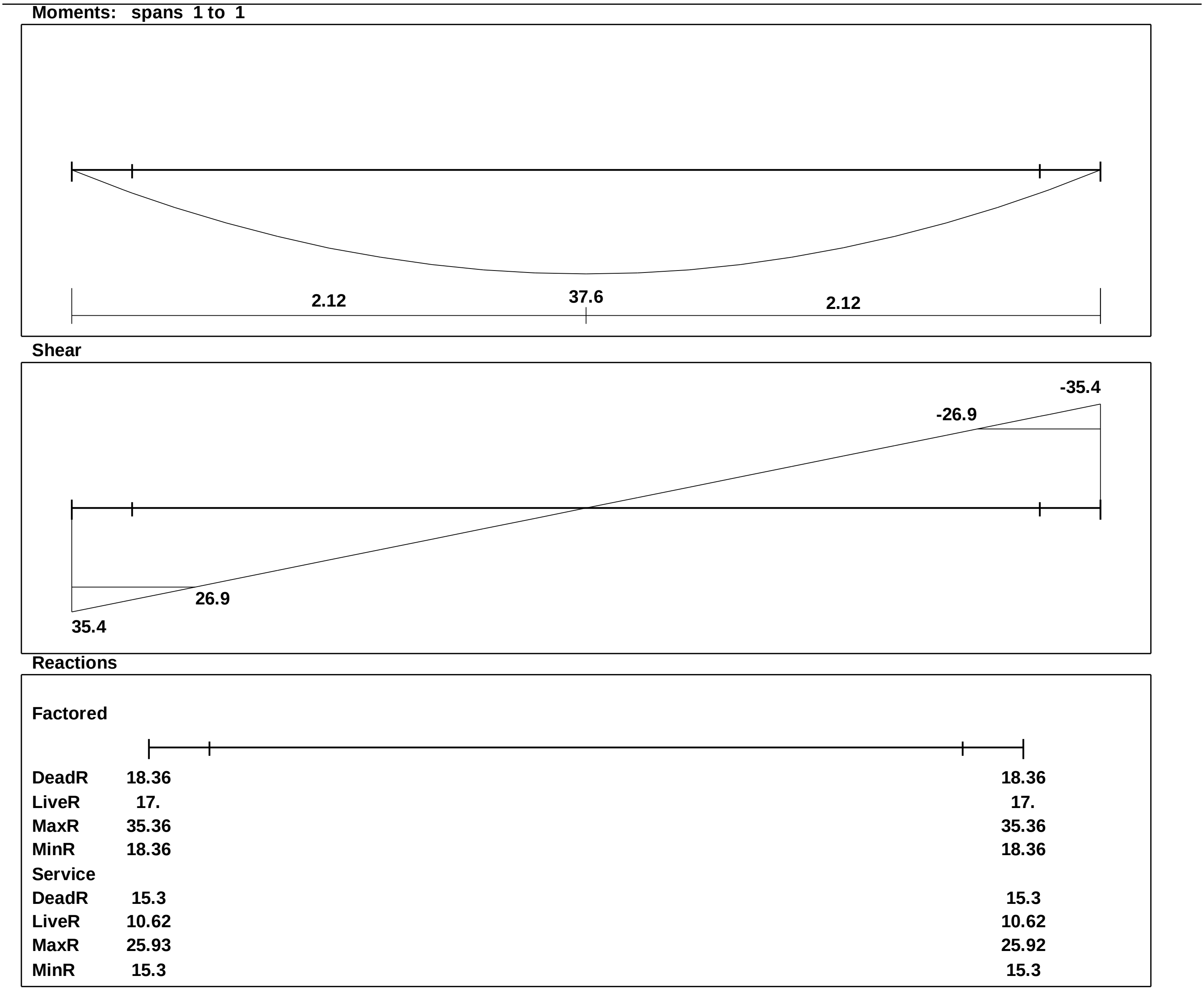


Fig 4.19 : Shear and moment envelop diagram

After enter these data to ATIR program

Design Of Basement Wall

2- Design of Shear:- (Vu= 35.4 KN)

Assume bar diameter ø 12 for main reinforcement

d =h- cover $-\frac{d_b}{2} = 300 - 75 - \frac{12}{2} = 219\ mm$

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d == \ \frac{1}{6}\sqrt{24} * 1000 * 219 = 178.8$ KN

$\Phi * V_c = 0.75 * 178.8 = 134.1$ KN> Vu = 35.4 KN…… **Thickness Is Enough (No need for shear)**

2- Design of Bending Moment (Mu=37.6KN/m) :-

d =h- cover $-\frac{d_b}{2} = 300 - 75 - \frac{12}{2} = 219\ mm$

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{37.6\times10^6}{0.9\times1000\times219^2} = 0.87\ Mpa$

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

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2\times20.6\times0.87}{420}}\right) = 0.00212$

$A_{s,req} = \rho.b.d = 0.00212\times1000\times219 = 464.3\ mm^2$

Check for $A_{s,\ min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420} * 1000 * 219 = 638.6\ mm^2$

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420} * 1000 * 219 = 730\ mm^2$ **Controls**

Use ø12 @150 mm , $A_{s,provided}$= 754 mm^2 > $A_{s,required}$= 730 mm^2… Ok

3- Design of horizontal and minimum vertical

$A_{s,h} = \rho.b.h = 0.00212\times1000\times300 = 636\ mm^2$

For each side : As = 636/2 = 318 mm^2

Use ø10 @ 200 mm for each side , $A_{s,provided}$= 395 mm^2 > $A_{s,required}$= 318 mm^2… Ok

$As_{vmin} = \rho.b.h = 0.002\times1000\times300 = 600\ mm^2$…. 300 mm2 for each side

Use ø10 @ 250 mm for each side , $A_{s,provided}$= 316 mm^2 > $A_{s,required}$= 300 mm^2… Ok

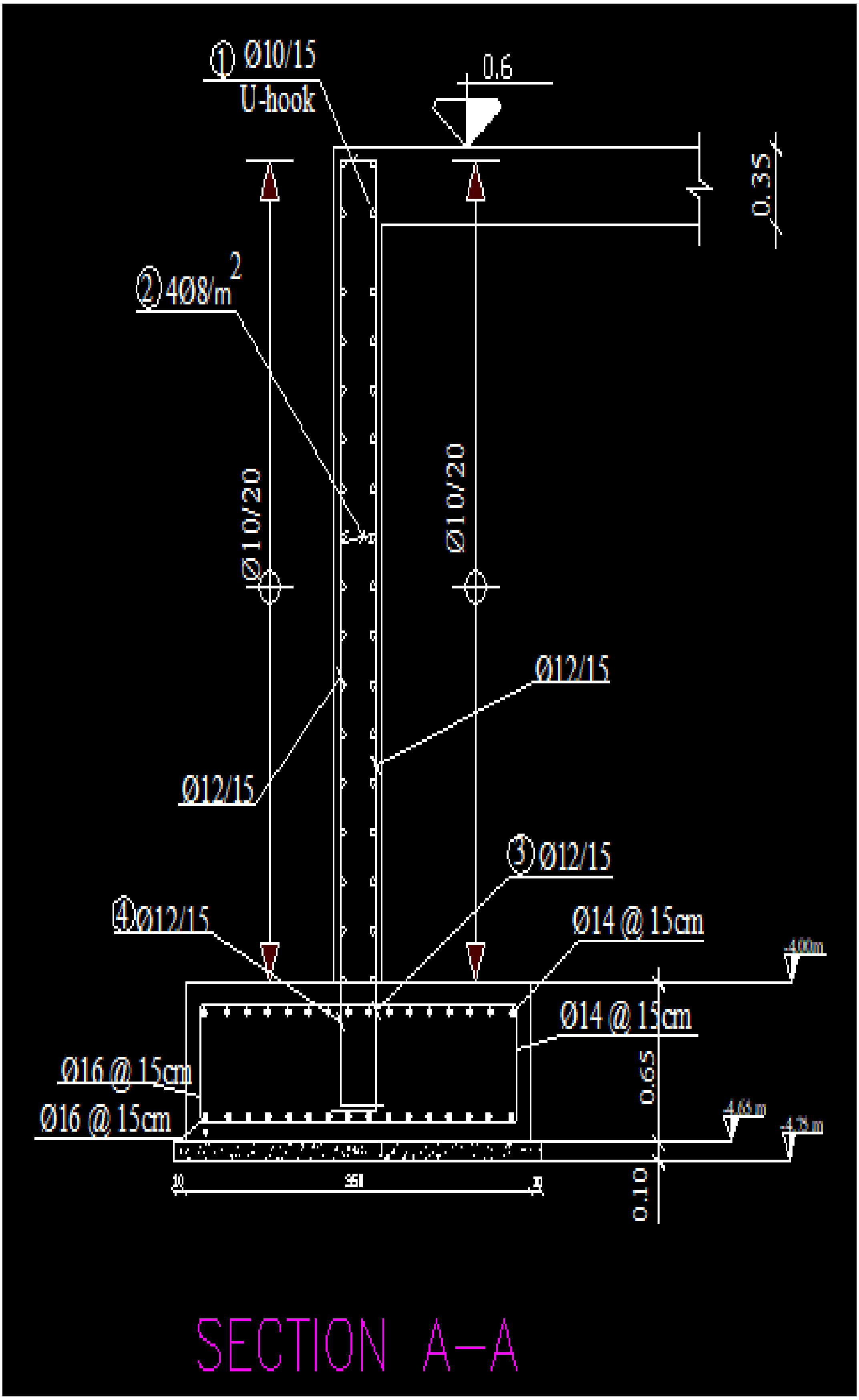


Fig 4.20: Basement wall details

4-10 Design of Shear Wall (3)

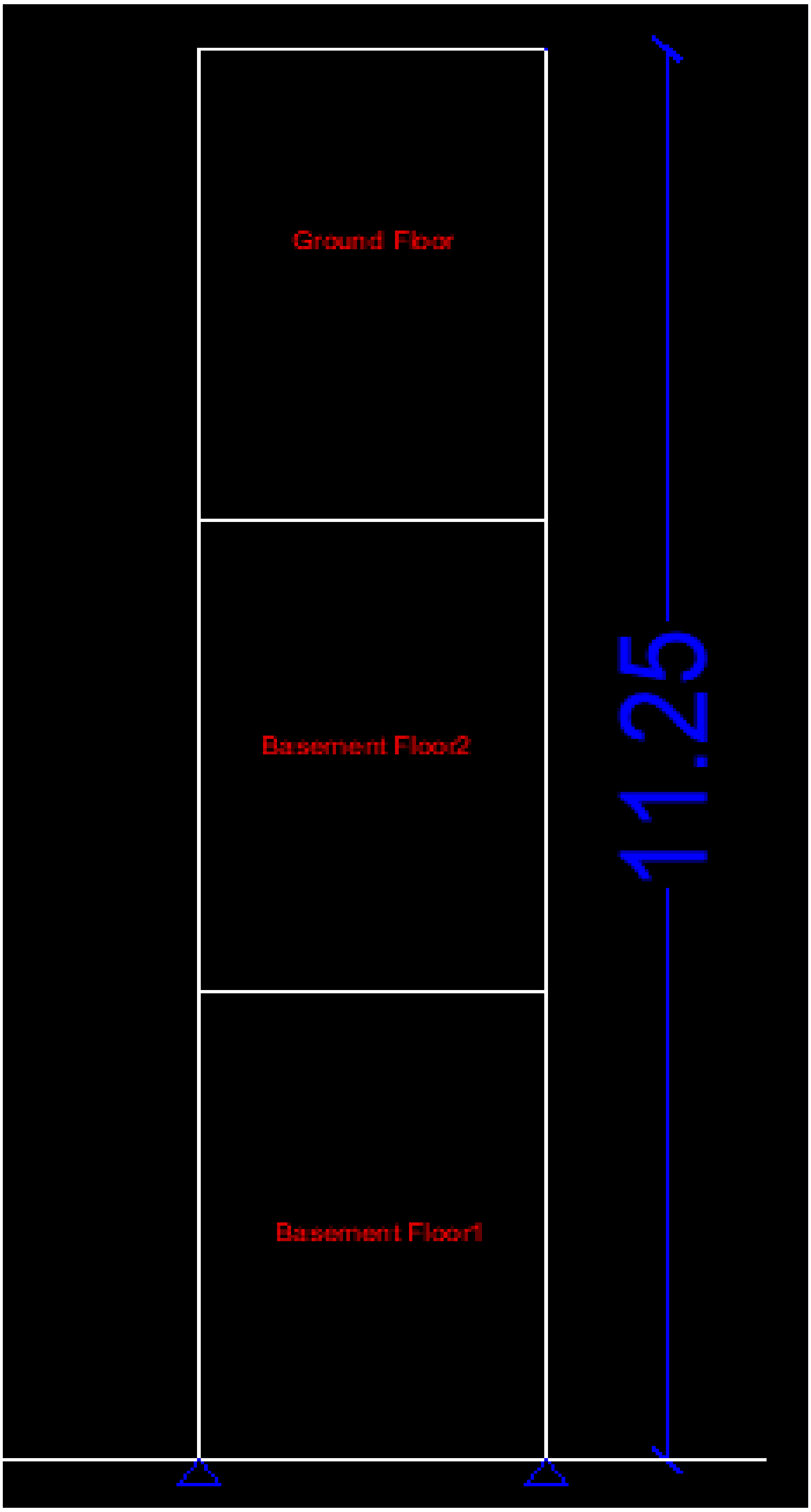


Figure (4-21): Shear Wall(3).

✓ **Material and Sections:- (From Shear Wall 3)**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

⇒ Shear Wall Thickness h = 20 cm

⇒ Shear Wall Width Lw = 2.48 m

⇒ Shear Wall Height Hw = 11.25m

4-10-1 Design of Horizontal Reinforcement:-

$$\sum Fx = Vu = 520.32 \ KN$$

The critical Section is the smaller of:

$$\frac{lw}{2} = \frac{2.48}{2} = 1.24m.......Control$$

$$\frac{hw}{2} = \frac{11.25}{2} = 5.625m$$

$$storyheigh(Hw) = 3.75m$$

$$d = 0.8 \times Lw = 0.8 \times 2.48 = 1.98m$$

$$\emptyset V_{nmax} = \emptyset \frac{5}{6}\sqrt{f_c{}'}hd$$

$$= 0.75 * 0.83 * \sqrt{24} * 200 * 1980 = 1207.3\ KN > V_u = 890.19KN$$

V_c is the smallest of :

$$1 - V_c = \tfrac{1}{6}\sqrt{f_c{}'}hd = \tfrac{1}{6}\sqrt{24} * 220 * 1980 = 323.33KN \text{ ….. control}$$

$$2 - V_c = 0.27\sqrt{f_c{}'}hd + \frac{N_u d}{4l_w} = 0.27\sqrt{24} * 200 * 1980 + 0 = 523.8KN$$

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

$$3 - V_c = \left[0.05\sqrt{24} + \frac{2.48\left(0.1\sqrt{24} + 0\right)}{0.5925}\right]200 * 1.98 = 909KN$$

SO ….Vc =323.33KN

$\emptyset * vc + \emptyset vs = vu$

$\emptyset * vs$=vu-$\emptyset * vc$

Vs=vu/$\emptyset - vc$

Vs=520.32/0.75-323.33= 370.4kn **need reinforcement**

$$\frac{A_{vh}}{S_2} = \frac{v_s}{f_y\ d} = \frac{370.4}{420 * 1980} = 0.000445\ m2/m$$

$$\rho_t = \frac{A_{vh}}{S_2 * h} = \frac{0.000445}{0.2} = 0.0023 < 0.0025$$

- Maximum spacing is the least of :

$\frac{Lw}{5} = \frac{2480}{5}$ = 496 mm

3*h = 3*200 = 600mm

450 mm ……. Control

Select $\emptyset 10$,tow layers

Sh=157/0.75=209.33

$$\rho_t = \frac{A_{vh}}{S_2 * h} = \frac{2 * 78.5}{S_2 * 200} = 0.0025$$

Sh=209.33

Select Sh=200mm≤Smax= 450 mm.

4-10-2 Design of Vertical Reinforcement:-

$$\frac{A_{vv}}{S_v} = 0.0025 + 0.5\left(2.5 - \frac{h_w}{Lw}\right)(\rho_t - 0.0025) \geq 0.0025$$

$$\frac{h_w}{Lw} = \frac{11.25}{2.48} = 4.53$$

$for\ this\ wall\ with\ \frac{h_w}{Lw}$ ≥2.5,$\rho_t = 0.0025$

- Maximum spacing is the least of :

$\frac{Lw}{3} = \frac{2480}{3}$ = 826.67 mm

3*h = 3*300 = 900mm

450 mm ……. Control

Use ϕ10/200 mm for two layers

4-10-3 Design of Bending Moment:-

$$A_{st} = \left(\frac{2480}{200}\right) * 2 * 79 = 1959.2mm^2$$

$$w = \left(\frac{A_{st}}{L_w h}\right)\frac{f_y}{f_c'} = \left(\frac{1959.2}{2480 * 200}\right)\frac{420}{24} = 0.069$$

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

$$\frac{C}{l_w} = \frac{w+\alpha}{2w + 0.85\beta_1} = \frac{0.069 + 0}{2 * 0.069 + 0.85 * 0.85} = 0.08$$

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

$$= 0.9[0.5 * 1959.2 * 420 * 2480(1 + 0)(1 - 0.08)] = 8448.5KN \geq 2953.2KN.m$$ …. Ok

$$X \geq \frac{Lw}{600*0.015} = \frac{2480}{600*0.015} = 275.55$$

$$Lb \geq \frac{X}{2} = 137.8$$

Since Smallest value of Lb & Mub not require Boundary .

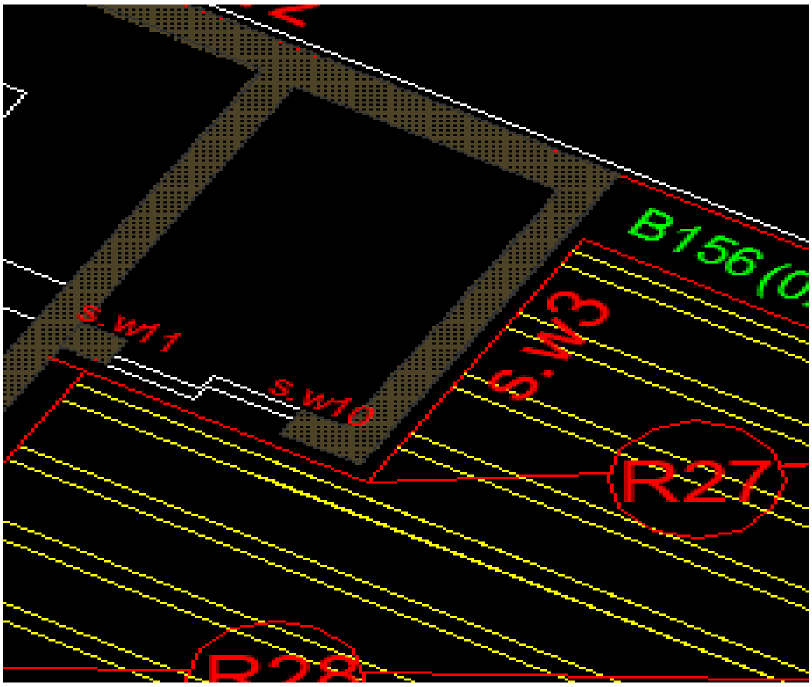


Figure (4-22): figure of Shear wall

4-11 | **Design of isolated Footing(F1):**

4-11-1 Materials and Loads:

Isolated footing that we consider to design with materials of:

$$f_{c'} = 24\ Mpa\ , f_y = 420\ Mpa\ .$$

Dead Load (service) $= 574kN.$
Live Load (service) $= 151\ kN.$
Total services load $= 574 + 151 = 725\ kN.$
Total Factored load $=\ 1.2(574) + 1.6(151) = 931\ kN.$
Column dimension $(\ a \times b) = 60cm \times 40cm.$
Soil density $= 18(\frac{kg}{cm^2}).$
Allowable bearing capacity $q_{all} = 400\ (\frac{kN}{m^2})$

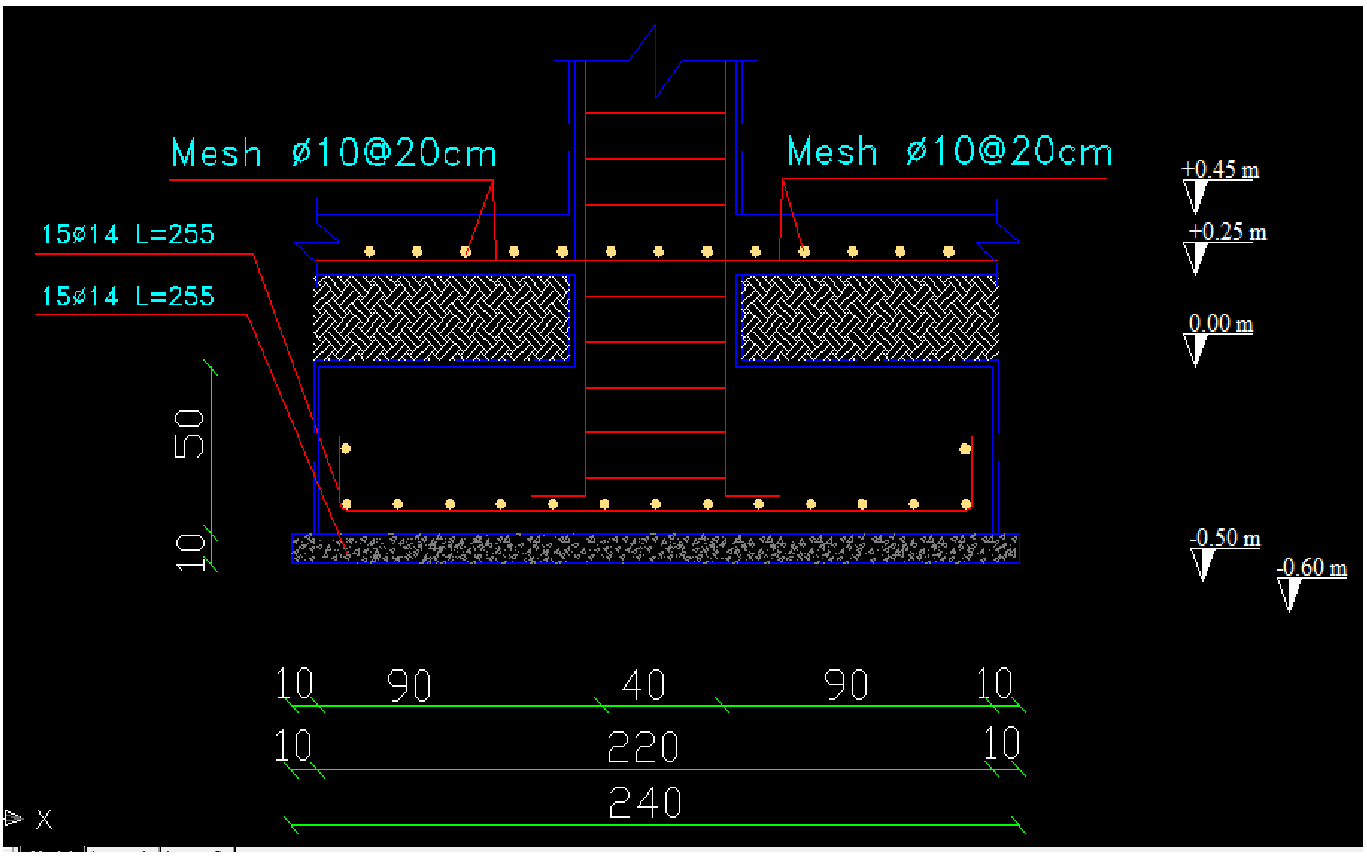


Figure (4-23): Footing Section.

Assume $h = 50cm$.

$q_{all-net} = 400 - (25 \times 0.5) - (18 \times 0.5) = 378.5 \ (\frac{kN}{m^2})$

- **Area of footing:**

$$A = \frac{p_t}{q_{all-net}} = \frac{725}{378.5} = 1.92 \ m^2$$

Assume rect. Footing

Select $B = 2.2 \ m$

Select $L = 2.2m$

- **Bearing pressure:**

$$q_u = \frac{931}{2.2 \times 2.2} = 131.4 \ (\frac{kN}{m^2})$$

4-11-2 Design:

- **Design of one-way shear strength:**

Critical Section at Distance d From The Face of Column Assume $h = 50 \ cm$.
Bar diameter $\emptyset 14$ for main reinforcement and 7.5 cm Cover.

$$d = 500 - 75 - 14 = 411mm$$

$$V_u = q_u \times \left(\frac{B-a}{2} - d\right) \times L = 131.4 \times \left(\frac{2.2-0.2}{2} - 0.411\right) \times 2.2 = 170.3 \ kN$$

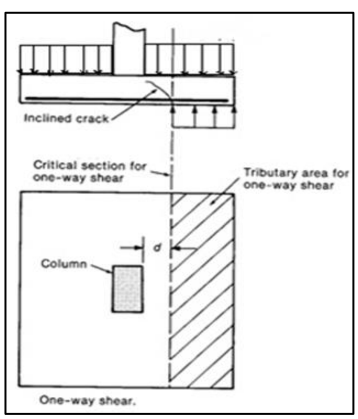


Figure (4-24): one-way shear calculation.

$$\emptyset V_C = \emptyset \times \frac{1}{6} \times \sqrt{f_{c'}} \times b \times d = 0.75 \times \frac{1}{6} \times \sqrt{24} \times 2200 \times 411 = 553.7\ kN$$

$$\emptyset V_C = 553.7kN > V_u = 170.3kN - Safe$$

- **<u>Design of Tow-way shear strength:</u>**

$$V_u = p_u - FR_b$$

$$FR_b = q_u \times area\ of\ critical\ section$$

$$V_u = 170.3 \times [(2.2 * 2.8) - (0.5 + 0.411)(0.5 + 0.411)] = 907.7\ kN$$

The <u>punching shear strength</u> is the smallest value of the following equations:

1. $\emptyset V_C = \emptyset \times \frac{1}{6}\left(1 + \frac{2}{\beta_c}\right) \times \sqrt{f_{c'}} \times b_\circ \times d$
2. $\emptyset V_C = \emptyset \times \frac{1}{12}\left(\frac{\alpha_s}{\frac{b_\circ}{d}} + 2\right) \times \sqrt{f_{c'}} \times b_\circ \times d$
3. $\emptyset V_C = \emptyset \times \frac{1}{3} \times \sqrt{f_{c'}} \times b_\circ \times d$

Where:

$$\beta_c = \frac{column\ Length\ (a)}{column\ width\ (b)} = \frac{60}{40} = 1.5$$

$$b_\circ = Perimeter\ of\ critical\ section\ taken\ at\ (d/2)\ from\ the\ loaded\ area.$$

$$= 2 \times (0.6 + 0.411) + 2 \times (0.4 + 0.411) = 384.2cm$$

$$\alpha_s = 40\ for\ interior\ coulmn$$

Substituting values in equations:

$$\emptyset V_C = 0.75 \times \frac{1}{6}\left(1 + \frac{2}{1}\right) \times \sqrt{24} \times 3842 \times 411 = 2900.9kN - CONTROL$$

$$\emptyset V_C = 0.75 \times \frac{1}{12}\left(\frac{40 * 0.511}{4.044} + 2\right) \times \sqrt{24} \times 3842 \times 411 = 3410.7\ kN$$

$$\emptyset V_C = 0.75 \times \frac{1}{3} \times \sqrt{24} \times 3842 \times 411 = 1933.9\ kN - CONTROL$$

$\emptyset V_C = 1933.9 kN > V_u = 907.7\ kN$

- **Design Bending moment for long dirction:**

Critical Section at the Face of Column

$select\ \emptyset 14$

d = 500-75-14 =411mm

$$M_u = 131.4 \times 2.2 \times 0.489 \times \frac{0.489}{2} = 34.6\ kN.m$$

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{34.6 \times 10^6}{0.9 \times 2200 \times 411^2} = 0.103\ MPa$$

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

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.103}{420}}\right) = 0.00025$$

$$A_{S,req} = \rho \times b \times d = 0.0025 \times 2200 \times 411 = 223.3mm^2$$

$$A_{Smin} = 0.0018 \times 2200 \times 500 = 1980\ mm^2$$

$$A_{S,req} = 223.3\ mm^2 < A_{Smin} = 1980mm^2 - OK$$

Check maximum step (S) is the smallest of:

1. $3h = 3 \times 500 = 1500mm$
2. $450\ mm - control$

$$Use\ 17\emptyset 14\ with\ A_{s,prov} = 2040mm^2 > A_{S,req} = 1980\ mm^2$$

S=(2200-75*2-17*14) / 16 = 113.4 mm

S=123.4 < Smax =450 mm, select S=100mm

Check for strain:

$$a = \frac{A_{s.f_y}}{0.85b\, f'_c} = \frac{2040 \times 420}{0.85 \times 2200 \times 24} = 19.1\ mm$$

$$c = \frac{a}{\mathcal{B}_1} = \frac{19.1}{0.85} = 22.5\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{411-22.5}{22.5}\right) = 0.0518 > 0.005\ \ \ldots\ldots 0k$$

- **<u>Design Bending moment for short direction:</u>**

  Critical Section at the Face of Column

$select\ \emptyset 14$

d = 500-75-14 =411mm

$$M_u = 131.4 \times 2.2 \times 0.489 \times \frac{0.489}{2} = 34.6\ kN.m$$

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{34.6 \times 10^6}{0.9 \times 2200 \times 411^2} = 0.103\ MPa$$

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

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2 \times 20.58 \times 0.103}{420}}\right) = 0.00025$$

$$A_{S,req} = \rho \times b \times d = 0.0025 \times 2200 \times 411 = 223.3mm^2$$

$$A_{Smin} = 0.0018 \times 2200 \times 500 = 1980\ mm^2$$

$$A_{S,req} = 223.3\ mm^2 < A_{Smin} = 1980mm^2 - OK$$

Check maximum step (S) is the smallest of:

3. $3h = 3 \times 500 = 1500mm$

4. $450\ mm - control$

$$\color{green}{Use\ 17\emptyset 14}\ with\ A_{s,prov} = 2040mm^2 > A_{S,req} = 1980\ \ mm^2$$

S=(2200-75*2-17*14) / 16 = 113.4 mm

S=123.4 < Smax =450 mm, select S=100mm

Check for strain:

$$a = \frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{2040 \times 420}{0.85 \times 2200 \times 24} = 19.1\ mm$$

$$c = \frac{a}{\mathcal{B}_1} = \frac{19.1}{0.85} = 22.5\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{411-22.5}{22.5}\right) = 0.0518 > 0.005\ \ \dots\dots 0k$$

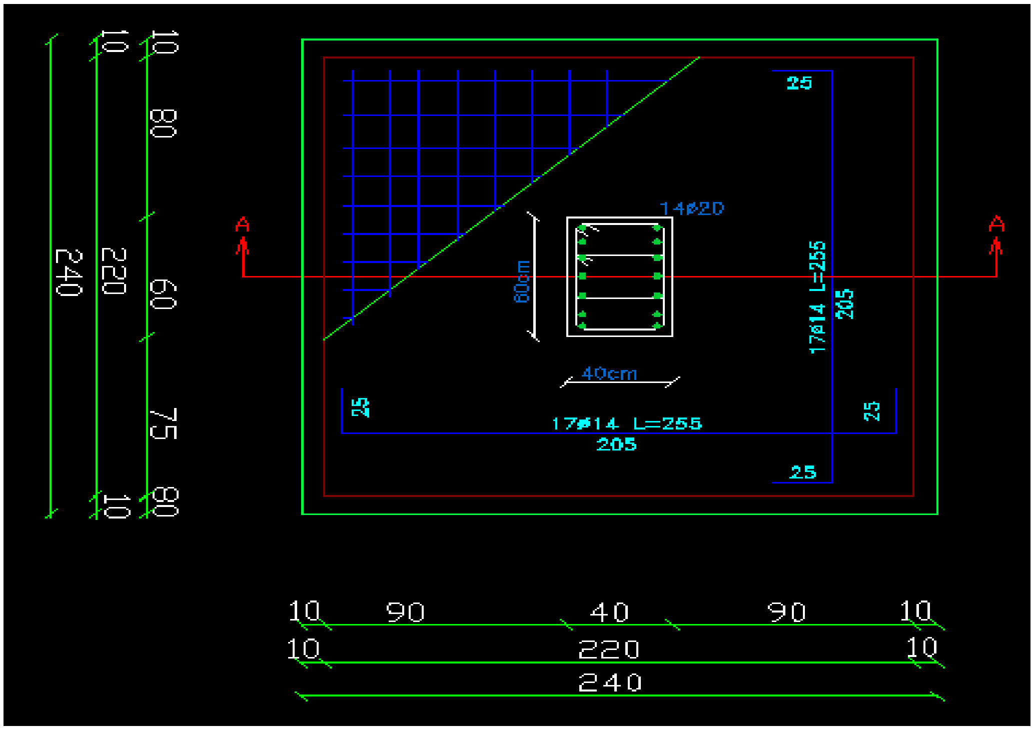


Figure (4-25): Detailing of footing.