بسم الله الرحمن الرحيم

Palestine Polytechnic University

College of Engineering

Department of civil Engineering

Graduation Project

“Structural design of an industrial high school”

Project Team:

Mahmoud Odeh **Shehabeddin Irfaeya**

Supervisor:

Eng. Bilal AL-Masri

Hebron-Palestine

2022 – 2023

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This project Submitted to the College of Engineering in partial fulfillment of the requirements for the degree of Bachelor's degree in Civil Engineering Branch of Building Engineering.

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In accordance with the recommendation of the project supervisor and acceptance of all examining committee members, this project has been submitted to the Department of Civil Engineering in the College of Engineering in partial fulfillment of the department's requirements for the degree of Bachelor of Building Engineering.

Signature of Project Supervisor

Name……………………………

Signature of Department Chairman

Name ………………………………..

2022 – 2023

الإهداء

إلهي لا يطيب الليل إلا بشكرك ولا يطيب النهار إلا بطاعتك ولا تطيب اللحظات إلا بذكرك ولا تطيب الآخرة إلا بعفوك ولا تطيب الجنة إلا برؤيتك

الله سبحانه جل في علاه جل جلاله..

إلى من بلغ الرسالة وأدى الأمانة ونصح الأمة إلى نبي الرحمة ونور العالمين، معلم البشرية ومنبع العلم

سيدنا محمد صلى الله عليه وسلم..

إلى من حاكت سعادتي بخيوط منسوجة من قلبها يا بسمة الحياة وسر الوجود يا من كان دعائها سر نجاحي وحنانها بلسم جراحي وركع العطاء أمام قدميها..

أمي الغالية..

إلى من أحمل اسمه بكل فخر ومن استلمت منه قيم الإنسانية وعلمتني ارتقي سلم الحياة بحكمة وصبر ستبقى كلماتك نجوم أهتدي بها اليوم وفي الغد وإلى الأبد يا صاحب القلب الكبير

والدي..

إلى رياحين حياتي يا من تطلعتم إلى نجاحي بنظرات الأمل ورافقتهم منذ أن حملت حقائب صغيرة

أخوتي..

إلى من معهم وبرفقتهم سرت وكانوا على طريق النجاح والخير وأمضيت معهم ذكريات الأخوة الذين تسكن صورهم وأصواتهم أجمل لحظات الأيام التي عشتها

أصدقائي..

إلى من هم أفضل منا جميعا الذين رووا بدمائهم ثرى فلسطين

كل الشهداء..

إلى من عشقوا الحرية وخاضوا بأمعائهم حربا من اجلك

اهدي هذه الثمرة المتواضعة لك

قدسي..

واخيراً وليس اخراً إلى جميع الأساتذة في دائرة الهندسة المدنية والمعمارية الذين لم يبخلوا بنصائحهم وتوجيهاتهم علينا

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“Structural design of an industrial high school”

Project Team:

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ABSTRACT

This project aims to learn the practical application of structural design based on the various structural theory courses studied in the previous semesters.

This project is the structural design of an industrial school located in Hebron with a total area of 4230 square meters.

This building consists of 4 floors:

The school has classrooms, laboratories, an administration area, an outdoor yard, a meeting room, a library, a car park and a lot of workshops.

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LIST OF ABBREVIATIONS

- **Ac =** area of concrete section resisting shear transfer.
- **As =** area of non-prestressed tension reinforcement.
- **A_s`=** area of non-prestressed compression reinforcement.
- **Ag =** gross area of section.
- **Av =** area of shear reinforcement within a distance (S).
- **At =** area of one leg of a closed stirrup resisting tension within a (S).
- **b =** width of compression face of member.
- **bw =** web width, or diameter of circular section.
- **C_c =** compression resultant of concrete section.
- **C_s =** compression resultant of compression steel.
- **DL =** dead loads.
- **d =** distance from extreme compression fiber to centroid of tension reinforcement.
- **Ec =** modulus of elasticity of concrete.
- **f_c` =** compression strength of concrete.
- **fy =** specified yield strength of non-prestressed reinforcement.
- **h =** overall thickness of member.
- **Ln =** length of clear span in long direction of two- 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 loads.
- **Lw =** length of wall.
- **M =** bending moment.
- **Mu =** factored moment at section.
- **Mn =** nominal moment.
- **Pn =** nominal axial load.
- **Pu =** factored axial load

- **S =** Spacing of shear in direction parallel to longitudinal reinforcement.
- **Vc** = nominal shear strength provided by concrete.
- **Vn** = nominal shear stress.
- **Vs** = nominal shear strength provided by shear reinforcement.
- **Vu** = factored shear force at section.
- **Wc** = weight of concrete.
- **W** = width of beam or rib.
- **Wu** = factored load per unit area.
- **Φ** = strength reduction factor.
- ε_c **=** compression strain of concrete = 0.003.
- ε_s **=** strain of tension steel**.**
- $\acute{\varepsilon}_s$ **=** strain of compression steel.
- **ρ** = ratio of steel area .

CHAPTER 1
" INTRODUCTION"

1.1 INTRODUCTION.

1.2 PROJECT OBJECTIVES.

1.3 WORK PROCEDURE.

1.4 PROJECT SCOPE.

1.5TIME LINE.

1.6 PROGRAMS USED IN THE PROJECT.

Figure 1: Expressive Image

1.1 INTRODUCTION

Engineering is the best way to harness natural resources to serve humanity.

In other words, it is the art of applying scientific principles and life experiences to our lives to improve the things we use or the facilities we live in. In general, it is the body that combines the available technical tools, activities and knowledge. It is the professional activity that uses imagination, wisdom and intelligence in the application of science, technology, mathematics and practical experience in order to be able to design, produce and manage processes that suit the needs of mankind.

Civil engineering affects many of our daily activities: the buildings we live in and work in, the transportation facilities we use, the water we drink, and the drainage and sewage systems that are necessary for our health and well-being, so civil engineering in general is the only way to make the world a more suitable and suitable place to live in.

Building engineering in particular is the engineering that takes care of providing the required housing with the required specifications, the required quality, and the resources available to each individual in the community , and it is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including public works such as roads, bridges, canals, dams, airports, sewage systems, pipelines, and construction components of buildings and railways.

1.2 PROJECT OBJECTIVES

After completing this project, we hope to achieve the following objectives:

1. Obtaining experience in solving the problems of each project in particular.
2. Improving the ability to choose the appropriate structural system for the project and distributing its structural elements on the plans, taking into account preserving the architectural character.
3. Gaining experience in reaching the best safe and economical design.
4. Using structural design programs and comparing them with theoretical solutions.

1.3 WORK PROCEDURE

To achieve the objectives of the project, the following steps were taken:

1. The architectural study in which the site, building plans and floor heights were studied.
2. Structural planning of the building, in which the type of slab is selected and the location of columns, beams and shear walls is determined, taking into account the architectural design.
3. A structural study in which all structural members are identified and the different loads are indicated
4. Was appreciated.
5. Analysis and design of the elements according to the ACI code using software and theoretical solutions.
6. Preparing construction drawings for all the elements in the building.
7. Writing a project where all these stages are presented in detail.

1.4 PROJECT SCOPE

This Project contains the following chapters:

CHAPTER 1: General introduction.

CHAPTER 2: Architectural description of the project.

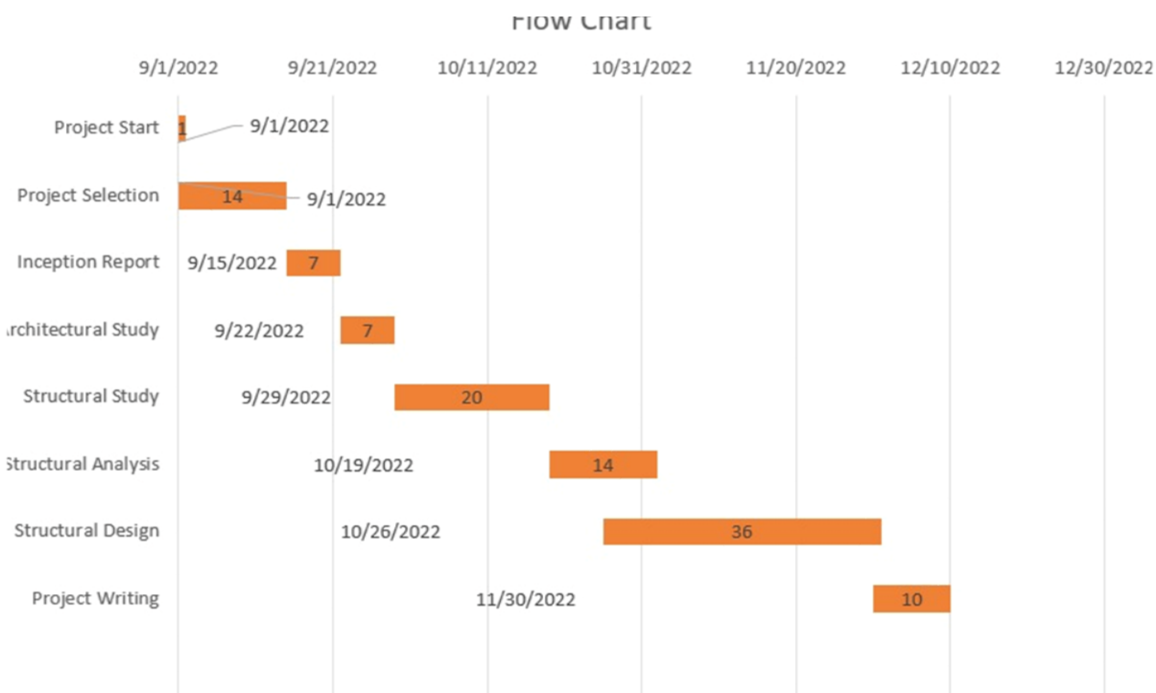
CHAPTER 3: General description of the structural elements.

CHAPTER 4: Structural analysis and design of all structural elements.

CHAPTER 5: Results and Recommendations.

1.5 TIME LINE

Table 1: Time Line



1.6 PROGRAMS USED IN THE PROJECT

1. Adoption of the American code in the various structural designs (ACI-318-19).
2. Using analysis and structural design programs such as (Atir12, Safe, Etabs,)
3. Other programs such as Microsoft office Word, Power Point, Excel.
4. AutoCAD.
5. Google Earth p

CHAPTER 2

" ARCHITECTURAL DESCRIPTION "

2.1 INTRODUCTION.

2.2 GENERAL IDENTIFICATION OF THE PROJECT.

2.3 FLOORS DESCRIPTION.

2.4 ELEVATIONS DESCRIPTION.

2.1 INTRODUCTION

Architecture is considered an art, talent, and idea, which derives its fuel from what God has bestowed upon the architect from the talents of beauty. With these talents, he moved from the life of the caves to the best form of luxury, taking advantage of the beauty God gave him of this picturesque nature, and if every art or science has controls and limits, architecture is not subject to any limitation or restriction, as it oscillates between imagination and reality. The result may be buildings of extreme simplicity and beauty.

The design process for any facility or building occurs through several stages until it is completed to the fullest, starting with the architectural design stage. The initial installation of the facilities, achieving the required spaces and dimensions, and in the process lighting, ventilation, movement, mobility, and other functional requirements are also studied.

Architectural designs should be easy to deal with and understand the various events and other things of importance that give a clear view of the project thus it will be possible to locate the columns and other structural elements in the structural design process that aims to determine the dimensions of the structural elements and their characteristics depending on the different loads that are placed on them. Transported through these elements to the foundations and then to the soil.

2.2 GENERAL IDENTIFICATION OF THE PROJECT

This school is consider one of a kind for how divers it is in the variety of how many majors it teach for a high school student such ass app development , graphical design and electric workshops .

Because of the nature of this school we considered so many things so we can be able to design it structurally flawless.

The building consists of four floors. The 2nd basement floor consists of a storage area and cafeteria with an area equal to 294 m^2, and the 1st basement floor consists of several workshops as mechatronics workshops, electric cars workshop and so on with three class rooms with an area equal to 1481 m^2. The ground floor consist of the administration sector, graphics workshop and class rooms with an area equal to 1338 m^2, and the last floor which is the 1st floor consist of dental technician workshop and a library with an area equal to 913 m^2 .

Area and Volume Schedule

Level	Area	height	Volume
01 Second Basement Floor Plan	294.41 m²	3.64	1071.64 m³
02 First Basement Floor Plan	1481.60 m²	4.68	6933.91 m³
03 Ground Floor Plan	1338.08 m²	3.64	4870.61 m³
04 First Floor Plan	913.07 m²	3.64	3323.56 m³
05 Staircase Floor Plan	39.81 m²	2.60	103.50 m³
05 Staircase Floor Plan	30.82 m²	2.60	80.12 m³
Grand total: 6	4097.78 m²		16383.34 m³

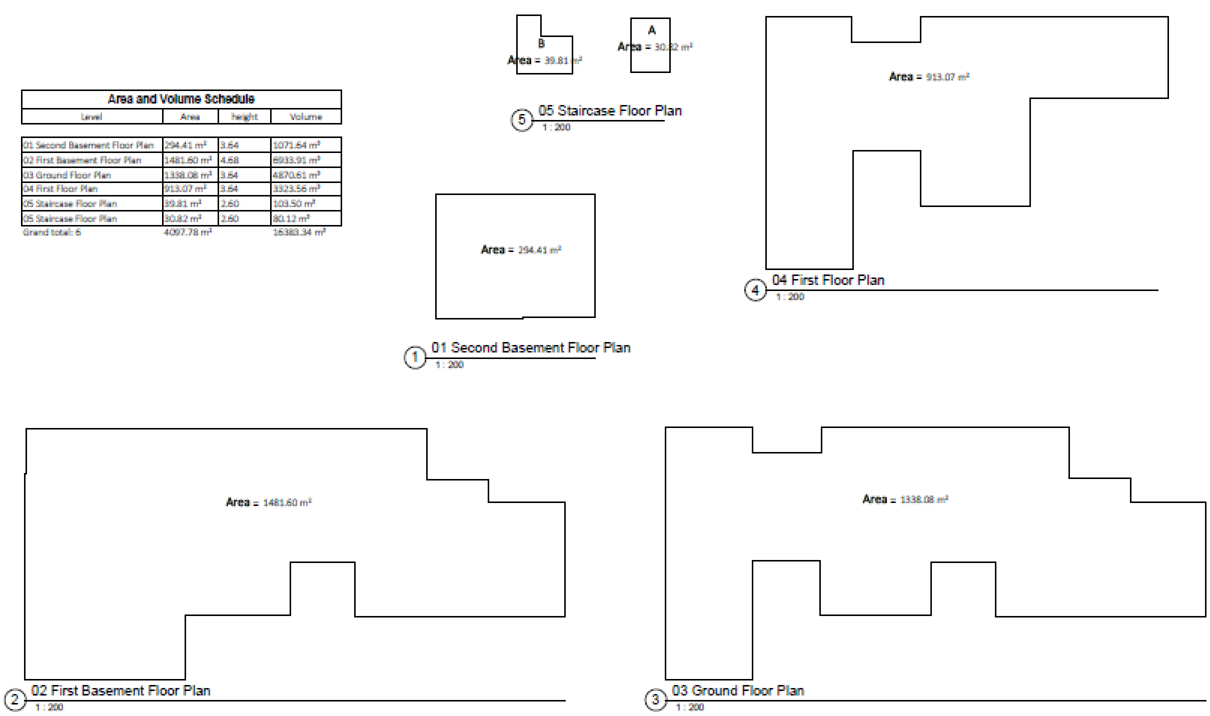


Figure 2: Building Areas

2.3 FLOORS DESCRIPTION

The project consists of four floors with a total area of 4027 m^{2}.

2.3.1 2nd Basement FLOOR:

(Level -8.32 m) with an area of 294 m^2.

The 2nd basement floor consists of a large storage area with cafeteria as shown in the figure (4)

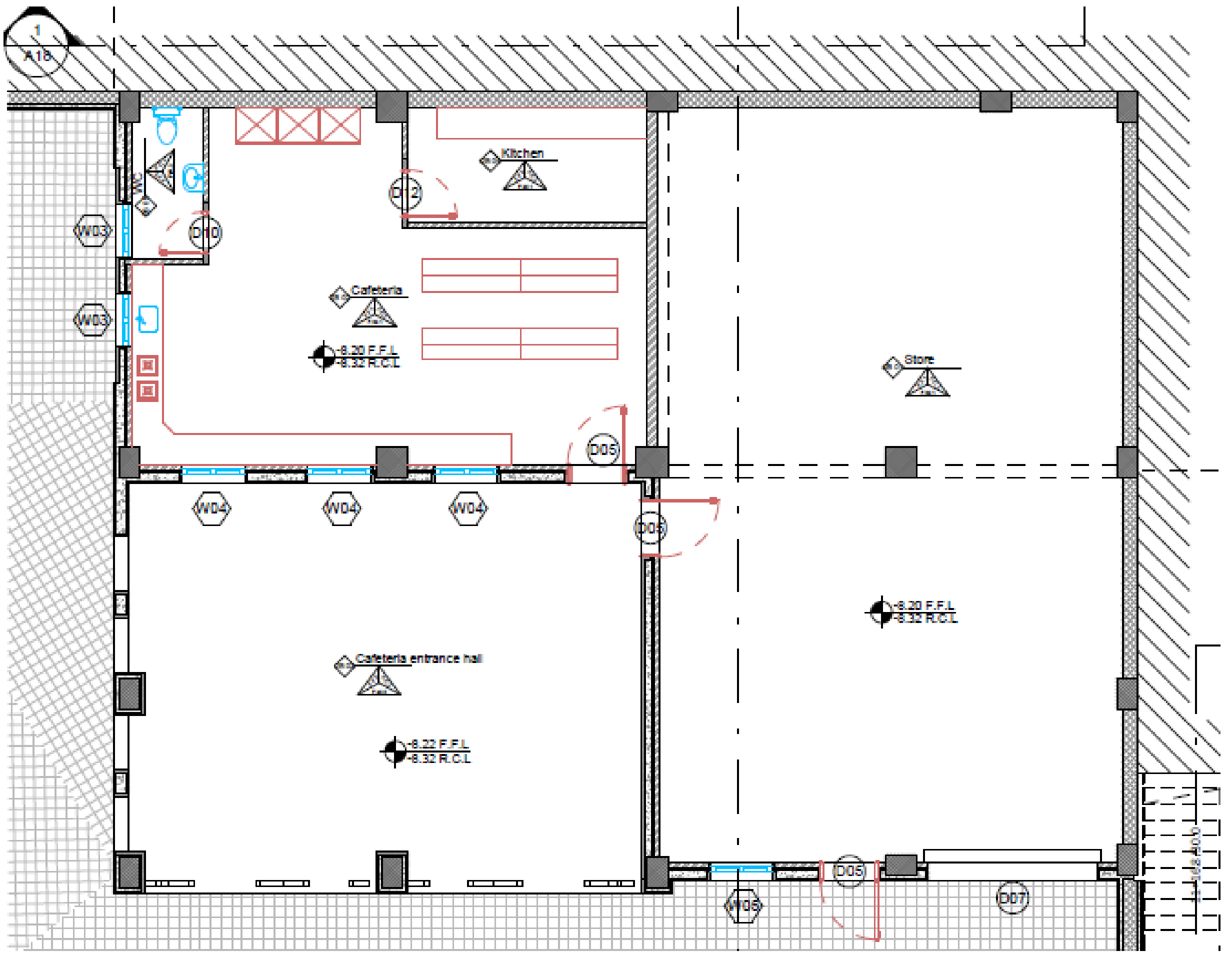


Figure 4: 2nd Basement Floor Plan

2.3.2 1^{st} Basement Floor:

(Level -4.68 m) with an area of 1481m^2

The 1^{st} Basement floor consists of mechatronics workshop, electric car workshop and class rooms as shown in Figure (6).

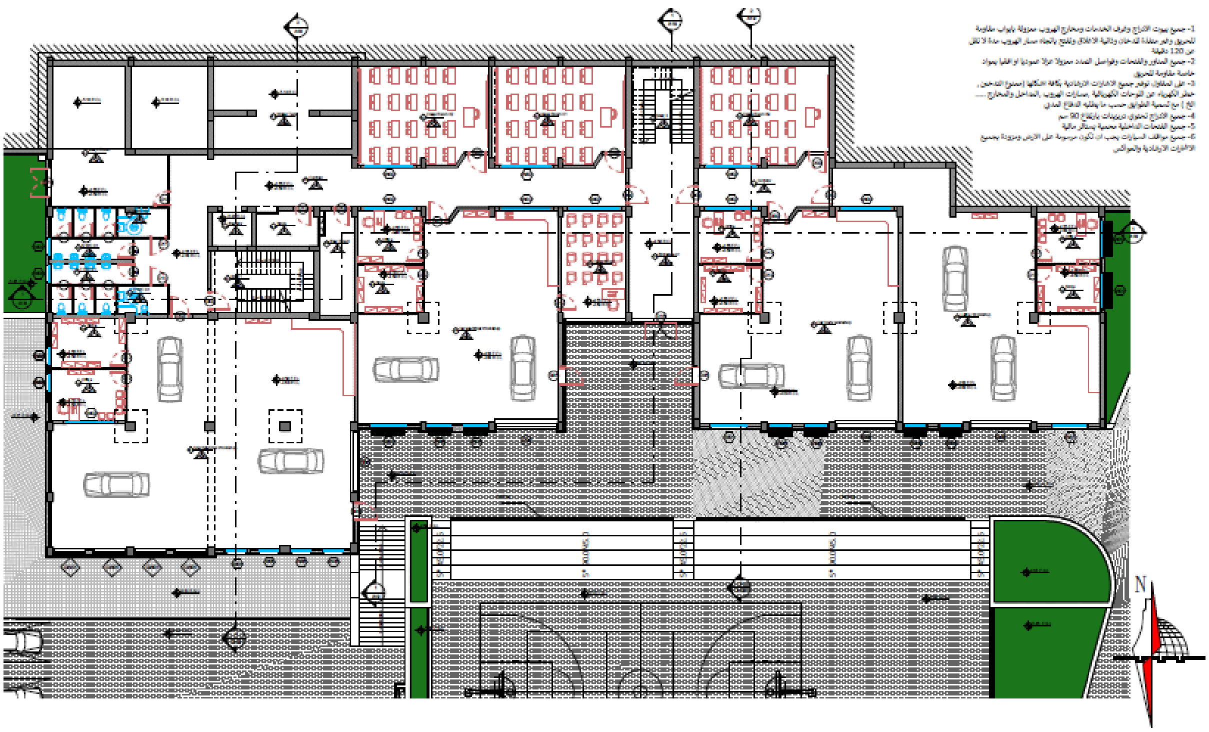


Figure 3: 1^{st} basement Floor Plan

2.3.3 Ground Floor:

(Level + 0.00 m) with an area of 1338 m^2.

The ground floor consist of the administration area, graphic workshop , app development workshop and class rooms as shown in Figure (7).

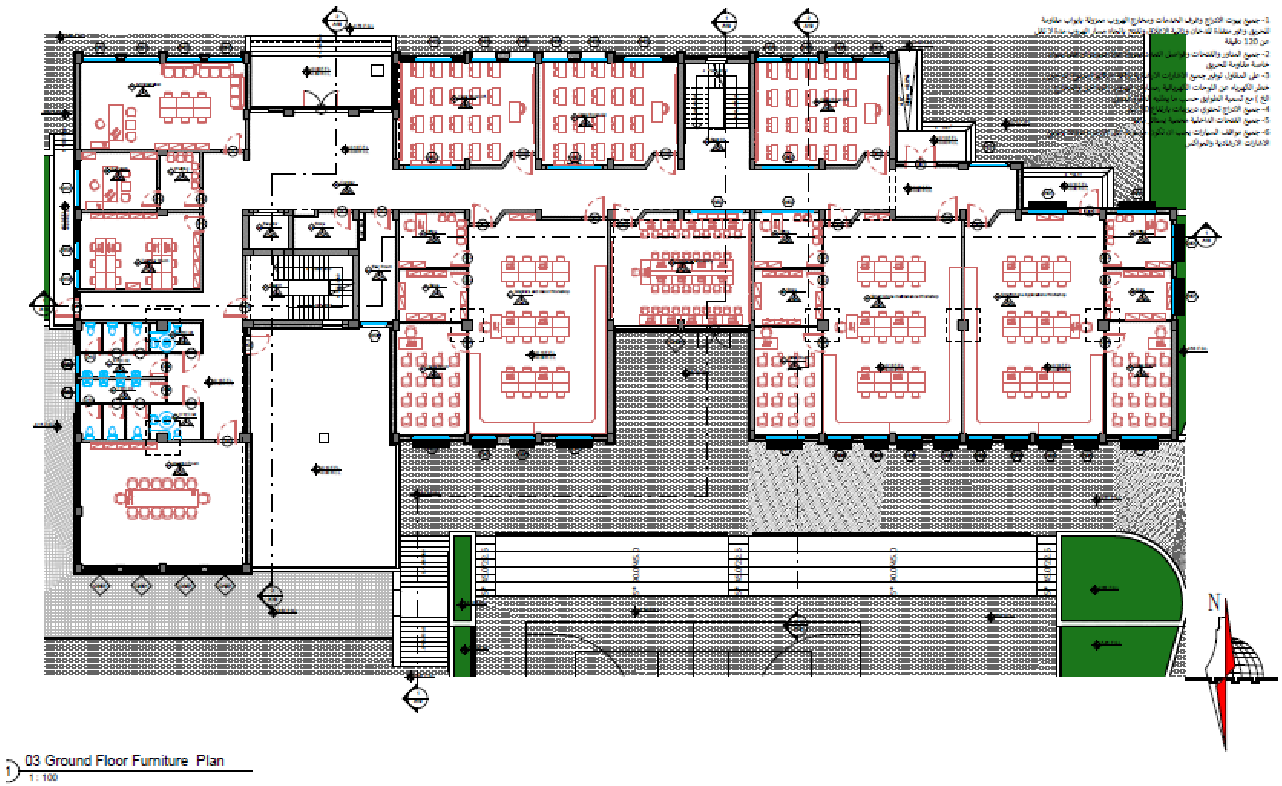


Figure 4: ground Floor Plan

2.3.4 First Floor:

(Level + 3.64 m) with an area of 913 m^2.

The first floor consist of a library, dental technician workshop and class rooms as shown in Figure (8).

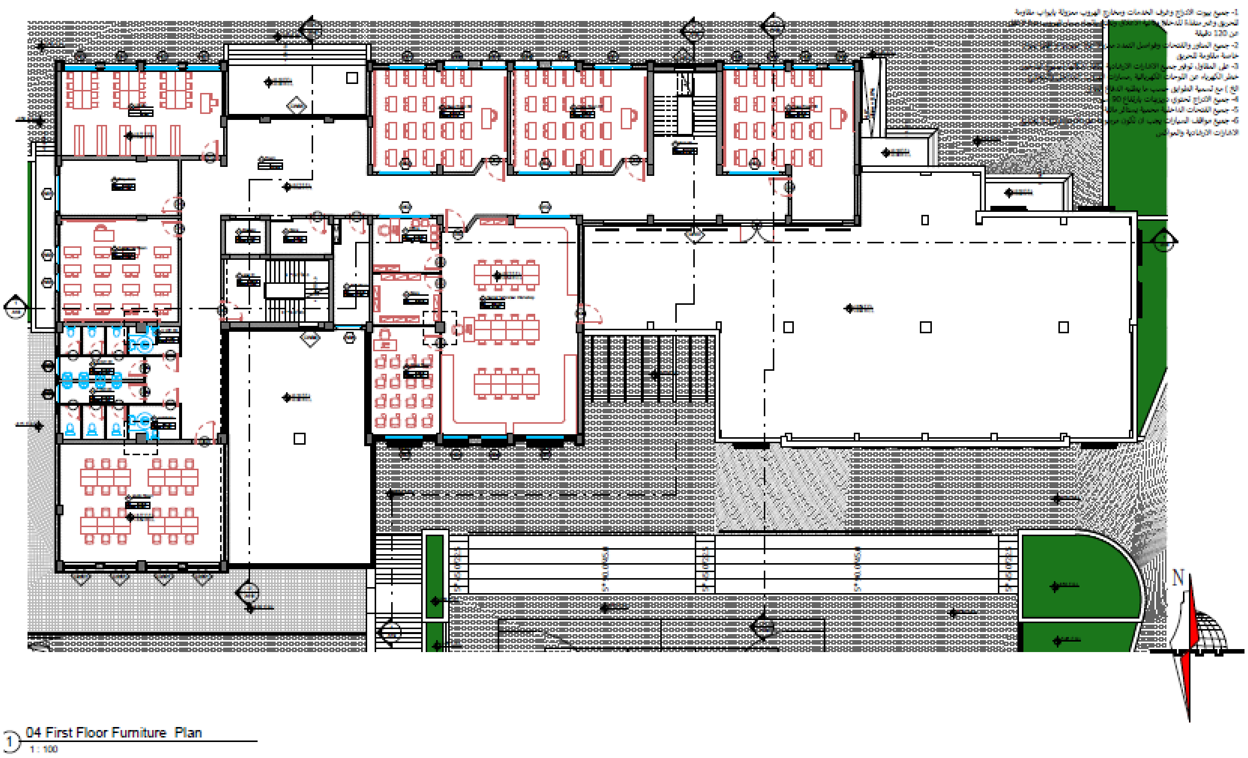


Figure 8: First Floor Plan

2.4 ELEVATIONS DESCRIPTION

The following is a description of different elements and components of the project elevations:

2.4.1 North Elevation:

The northern elevation shows the main entrance and the class rooms as shown in Figure (9).

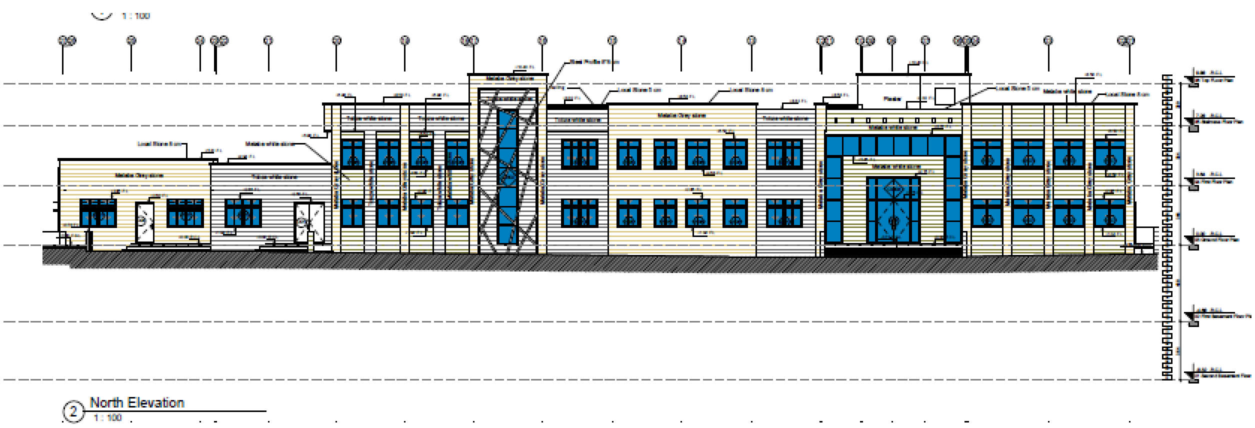


Figure 9: North Elevation

2.4.2 South Elevation:

The southern elevation shows the second main entrance, the workshops entrances and the storage with the cafeteria next to it as shown in the figure (10).

Figure 10: South Elevation

2.4.3 East Elevation:

The eastern elevation shows the entrance of the mechatronics workshops, as shown in Figure (11).

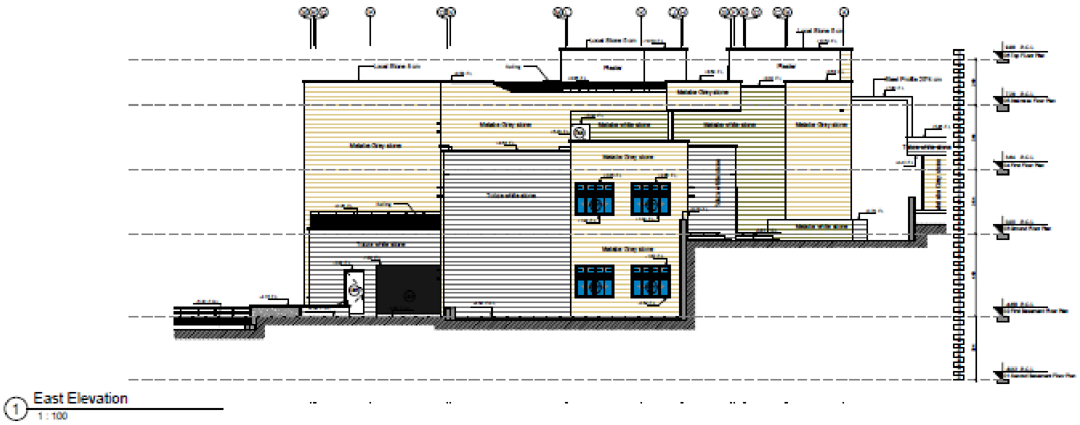


Figure 11 :East Elevation

2.4.4 West Elevation:

The western elevation shows a side entrance for the administration as shown in Figure (12).

Figure :12 West Elevation

CHAPTER 3
"STRUCTURAL DESCRIPTION"

3.1 INTRODUCTION.

3.2 THE AIM OF THE STRUCTURAL DESIGN.

3.3 LOADS ACTING ON THE BUILDING.

3.4 SCIENTIFIC TESTS.

3.5 STRUCTURAL ELEMENTS OF THE BUILDING.

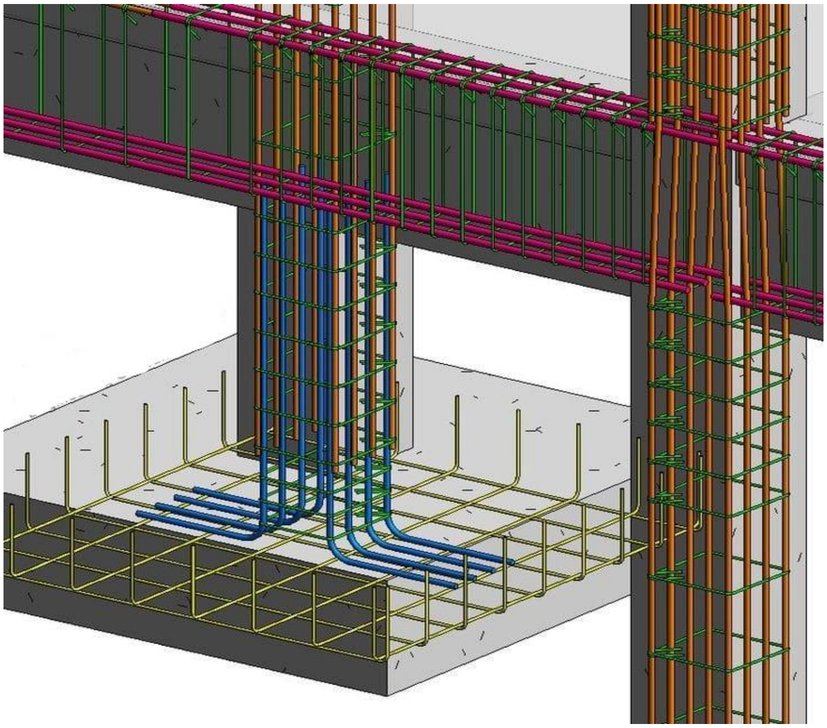


Figure 5: Expressive Image

3.1 INTRODUCTION

Structural design is a methodical investigation to get the economical specification of a structure or a structural element to carry the predicted load safely. With the application of structural design, we can obtain the required size, grade, reinforcement, etc. Of structural members to withstand the internal forces calculated from the structural analysis.

If the structure is not designed properly including proper selection of materials and technology or if the structure that we have designed is subjected to excessive load than the specified limit then it will probably fail to perform its intended function with possible damage both to structure and life, including complete damage.

3.2 THE AIM OF THE STRUCTURAL DESIGN

The following aims must be taken into consideration:

1. Ensure structural safety, which implies providing adequate stiffness and reinforcements to contain deflections and cracks.
2. Durability: The structure should last for a reasonable period.
3. Produce a structure that is capable to resist all applied loads without failure during its service life.
4. Obtain the economical dimensions of structural members. As any engineer can always design a massive structure, which has more than adequate stability, strength, and serviceability, but the ensuing cost of the structure may be exorbitant.
5. Stability to stop overturning, slipping, or buckling of the frame, or sections thereof, under load motion.
6. Investigate the strength and rigidity of structures.

3.3 STAGES OF STRUCTURAL DESIGN

Structural design stages can be divided into two main stages:

3.3.1 The First Stage:

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

3.3.2 The Second Stage:

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

3.4 LOADS ACTING ON THE BUILDING

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

3.4.1 Dead Load:

They are the loads resulting from the self-weight of the main elements that make up the structure, permanently and steadily, in terms of size and location, in addition to additional parts such as the various internal partitions and any mechanical works or additions that are carried out permanently and steadily in the building, and they can be calculated by determining the dimensions of the structural element, and the densities Its constituent materials, and Table (2) shows the specific densities of the materials used in the project.

Table 2:T The Specific Densities Of The Materials

MATERIALS USED	SPECIFIC DENSITIES USED (kN/m^3)
Reinforced concrete	**25**
Tiles	**22**
Mortar	**22**
Plaster	**22**
Sand Fill	**17**
Hollow block	**12**

Partition = 1.3 kN/m^2

3.4.2 Live Load:

In this project, all slabs are loaded with a residential load, in addition to the open terrace area, which has a different load, as it is an area in which various activities can be held, such as gatherings of people, parties, and others.

Live load values are chosen according to the Jordanian code tables:

Table 3 : Live Load from Jordanian

ا مل ا ركز البديل	ا مـل ا ـوزع	الاستعمال	نوع ا ب	
كن	كن/م٢	الاشغـال	خاص	عـام
7.0	4.8 لكل متر من ارتفاع التخـزين على أن لا يقل عن (10).	أماكن التكديس الكثيف للكتب علـى عربـات متحركة.	تابع السجون وا ستشفيات وا دارس والكليات.	تابع ا باـي التعليمية وماشابها.
7.0	2.4 لكل متر من ارتفاع التخزين على أن لا يقل عن (6.5).	غرف تكديس الكتب.		
9.0	4 لكل متر من ارتفاع التخزين.	مستودعات القرطاسية.		
4.5	5.0	ا مرات وا داخل ا عرضة ركـ ـة ا ركبـ ـات والعربات ا تحركة.		
9.0	5.0	غرف وقاعات التدريب.		
3.6	5.0	قاعات التجمع وا سارح وا منازيوم دون مقاعد ثابتة.		
4.5	3.0	ا ختـ ات ا فيها مـن أجهزة، وا طابخ وغرف الغسيل.		
2.7	3.0	ا مـ ـرات وا ـ ـداخل والأدراج و بـ ـسطات الأدراج الثانويـ ـة.		

3.4.3 Snow Load:

Snow loads depend on the height of the area above sea level, and the shape of the roof.

Table 4: Snow Loads

SNOW LOADS (KN /M²)	HEIGHT OF BUILDING ABOVE SEA LEVEL (H) (M)
0	**h < 250**
(h-250) / 1000	**500 > h > 250**
(h-400) / 400	**1500 > h > 500**
(h – 812.5)/ 250	**2500 > h > 1500**

3.5 SCIENTIFIC TESTS

Soil geotechnical examinations are the first step that is carried out before the structural design of the building. The type of soil at the site and its bearing capacity will determine the type of foundation suitable for the building.

Soil testing can be divided into two main components:

- Field soil sampling and analysis
- Lab tests

3.6 STRUCTURAL ELEMENTS OF THE BUILDING

3.6.1 Slabs:

After studying the building architecturally and structurally, the following types of slabs were used in the design:

- **One-way solid slab**

  A one-way slab is a type of concrete slab in which loads are transferred in one direction to the supporting beams and columns. Therefore, the bending occurs in only one direction. It is used in areas that are highly exposed to live loads.

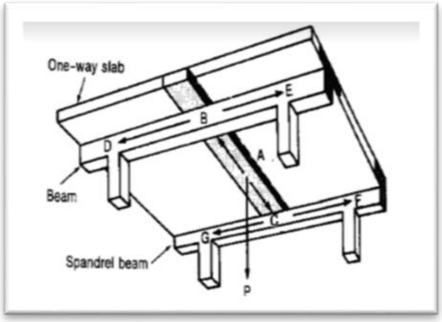


Figure 6: One-Way Solid Slab

- **Two-way solid slab**

  A slab supported on all four edges with an aspect ratio of longer to shorter theoretical span less than ≤2.00

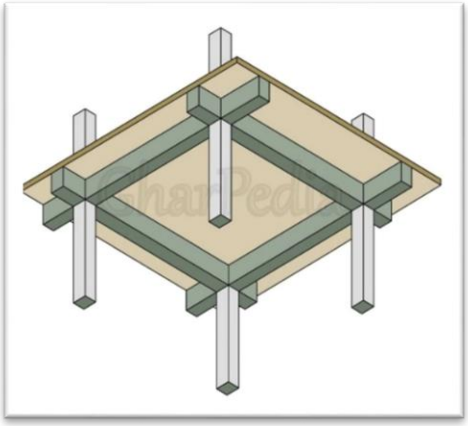


Figure 7: Two-Way Solid Slab

- **One-way ribbed slab**

It's the most common system used in Palestine. It consists of a row of bricks followed by the rib, and the reinforcement is in one direction

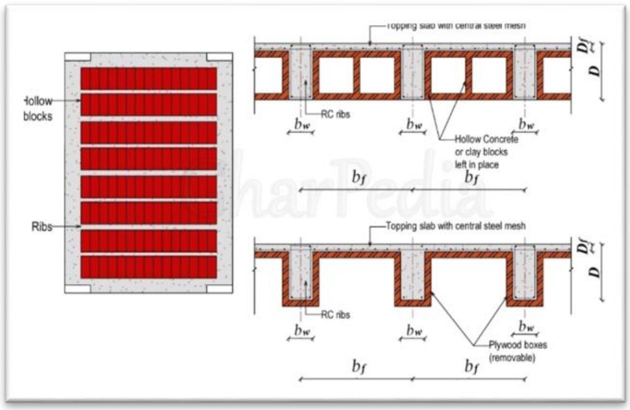


Figure 8: One-Way Ribbed Slab

3.6.2 Beams:

Beams act as structural elements that transfer loads from the slab to columns. They are typically horizontal members. In our project we used these types:

- Rectangular beams
- T-section beams

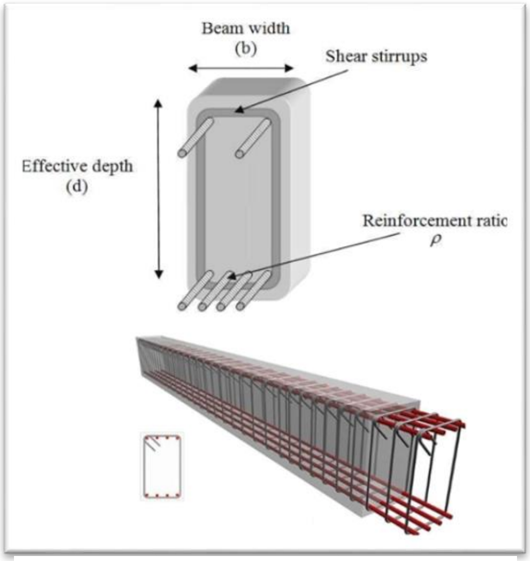


Figure 9: Rectangular Beam

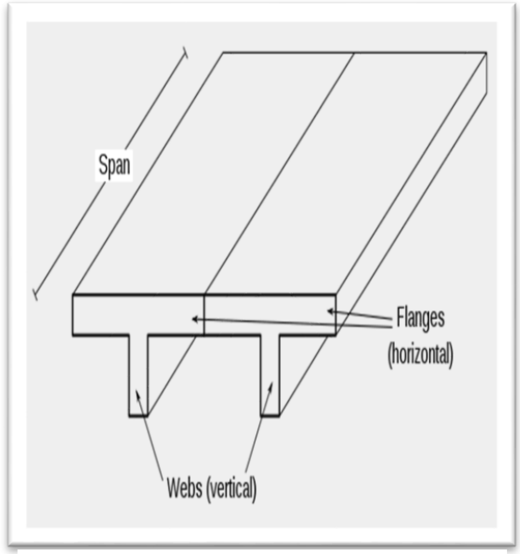


Figure 10: T-section Beam

3.6.3 Columns:

Columns act as a structural element that transfers loads from the slab, (i.e., roof, upper floor) to the foundation and finally to the soil under a structure. In our project we use:

- Continues columns

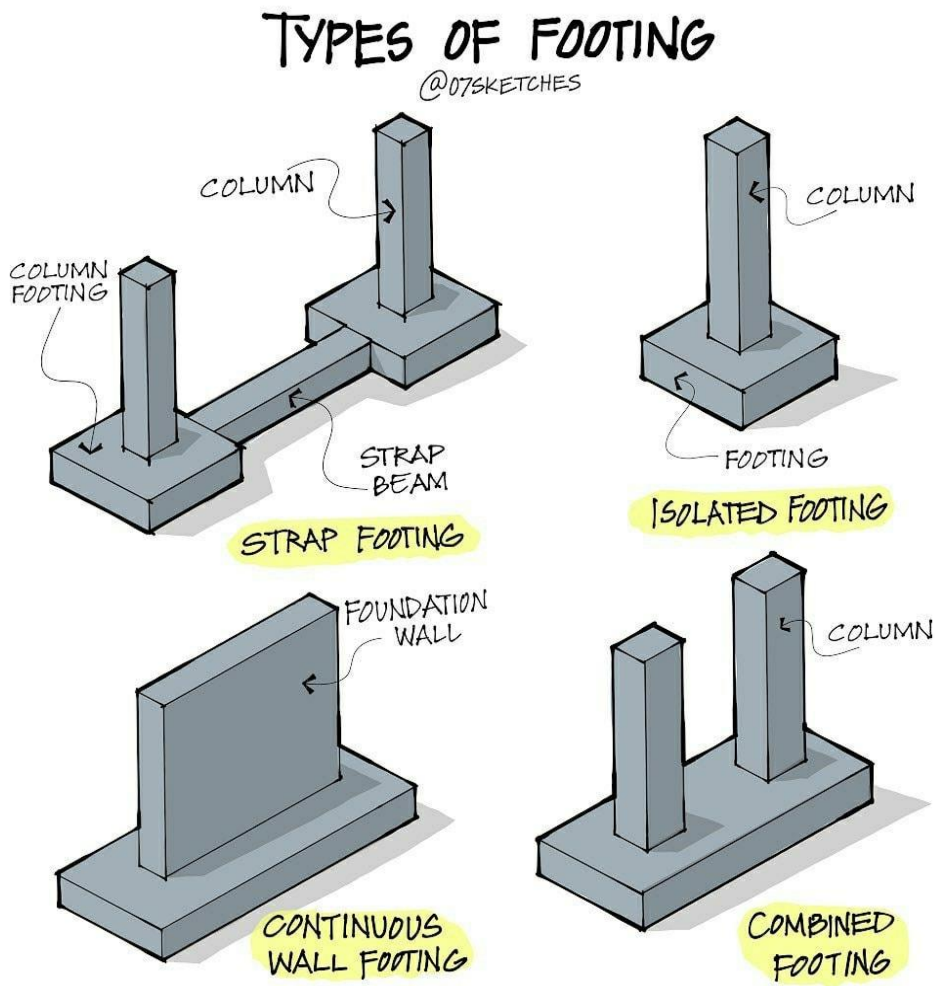
Figure 11: Continues Columns

3.6.4 Foundations:

The foundations are the first thing that begins to be implemented when building, but they are designed after designing all the basic elements in the building, as the foundations transfer loads from columns and load-bearing walls to the soil in the form of strength and pressure.

We have many types of foundation in our building such as

- Isolated footing
- Strip footing
- Matt footing



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3.6.5 Shear Walls:

Shear walls are the walls that resist horizontal forces such as wind forces and earthquakes, and be in the walls of the stairwell and the walls of the elevators

In our project we used:

- Continues shear wall
- Basement shear walls

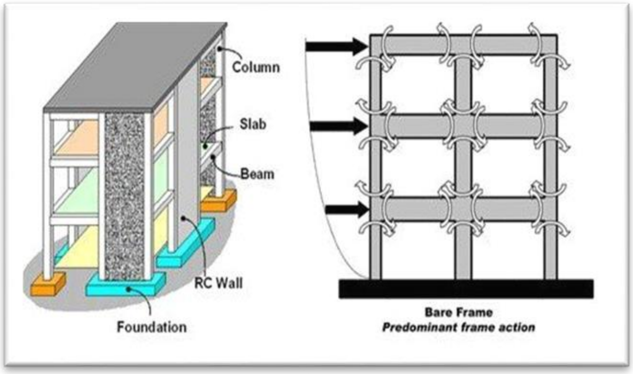


Figure 12: Shear Wall

3.6.6 Stairs:

The staircase is a movement element and a connection between the floors of the building

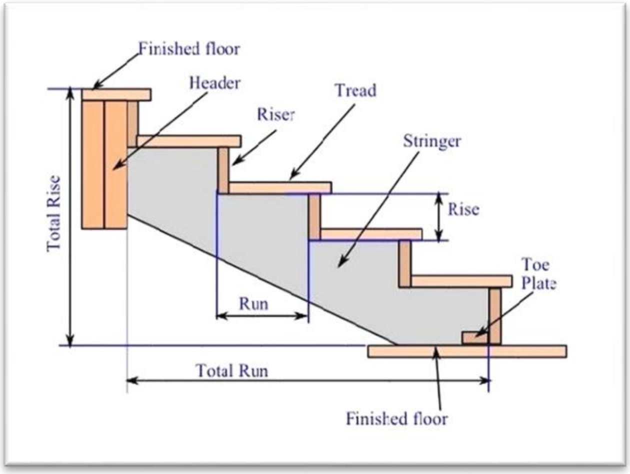


Figure 13: Stairs

CHAPTER 4
" STRUCTURAL ANALYSIS AND DESIGN"

4.1 INTRODUCTION

Normal plain concrete can withstand compressive stress but does not do well with tensile and stresses such as those caused by wind, earthquakes.

Reinforced concrete contains steel embedded in the concrete so the two materials complement each other to resist forces such as tensile, shear and compressive stress in the concrete structure.

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

4.2 DESIGN METHOD AND REQUIREMENTS

The design strength provided by a member is calculated according to the requirements and assumptions of ACI-code (318-19).

4.2.1 Ultimate Strength Design Method:

In this method, the reinforced concrete structure is designed beyond the elastic region. the working dead load and live load are multiplied by a factor of safety. the section designed to fail at factored load. failure at factored load means the section exceeds the elastic region to ultimate strength then failure.

The computation of this strength takes into account the nonlinear stress-strain behavior of concrete. The strength design method is expressed by the following,

Strength provided ≥ strength required to carry factored loads.

4.2.2 Materials:

Reinforced Concrete: B300 , $f_{\acute{c}}$ = 24 N/mm^2 (Mpa)

Reinforcement Rebars: f_y = 420 N/mm^2 (Mpa)

4.3 FACTORED LOAD

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

$$q_u = 1.2DL + 1.6LL \quad \text{……… } ACI - 318 - 14\ (9.2.1.)$$

Where;

q_u: Ultimate Load (KN)

D_L: Dead Load (KN)

L_L: Live Load (KN)

4.4 DETERMINATION OF SLAB THICKNESS

Minimum Thickness of Non prestressed Beam or One-Way Slabs Unless Deflections are Calculated. **(**ACI-Code-318-19**)**

Table 5 : Check Of Minimum Thickness Of Structural Member.

Minimum Thickness (h)				
Member	**Simply supported**	**One end Continuous**	**Both end continuous**	**Cantilever**
Solid one-way slabs	**L/20**	**L/24**	**L/28**	**L/10**
Beams or ribbed one-way	**L/16**	**L/18.5**	**L/21**	**L/8**

4.4.1 One-Way Solid Slab Thickness:

The final thickness of the slab will be determined based on the deformation that will be calculated through the design programs because the slab is originally one-way, but due to the difference in its behavior in some areas, the loads may be distributed in both directions.

4.4.2 One-Way Ribbed Slab Thickness:

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

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

= 502/18.5 = **27.1m.**

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

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

= 510/21 = **24.2 cm.**

Selected a preliminary slab thickness of the ribbed slabs thickness = 30 cm.

4.5 DESIGN OF TOPPING IN SECOND FLOOR

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

Dead Load For 1m strip = (0.1×25×1) + 1 = **3.5 KN/m**

Live Load For 1m strip = 5 KN/m^2 × 1 = **5 KN/m**

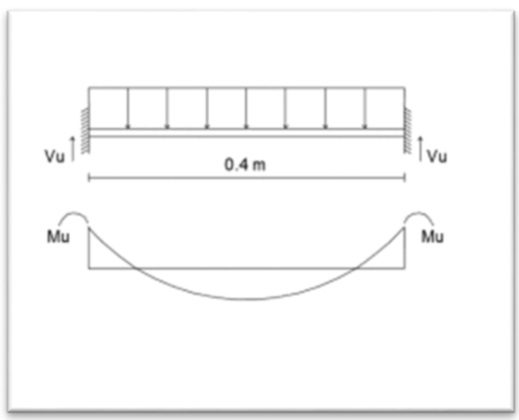


Figure 14: Topping Load

- ✓ Factored load:

W_u= 1.2 ×3.5 + 1.6×5 = 12.2 KN/m

- ✓ Check the strength condition for plain concrete:

$\emptyset M_n \geq M_u$, where $\emptyset$= 0.55

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

$$S_m = \frac{b.h^2}{6} = \frac{1000.100^2}{6} = 1666666.67\ mm^2$$

$\emptyset M_n = 0.55\times0.42\times1\times\sqrt{24}\times1666666.67\times10^{-6} = 1.8$ KN.m

$M_u = \frac{W_u L^2}{12} = 0.162\text{KN. m}$ (negative moment)

$M_u = \frac{W_u L^2}{24} = 0.08\text{KN. m}$ (positive moment)

$\emptyset M_n >> M_u = 0.162$ KN. m

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

$\rho_{shrinkage}$= 0.0018

$A_s = \rho\times b\times h_{topping} = 0.0018\times1000\times100 = 180\ mm^2$/m strip.

Step (s) is the smallest of:

1. 3h = 3×100 =300 mm …… ***control***
2. 450 mm.
3. $S = 380\left(\frac{280}{f_s}\right) - 2.5C = 380\left(\frac{280}{\frac{2}{3}(420)}\right) - 2.5\times20 = 330$ mm

Take Ø 8 @ 200 mm in both direction, S = 200 mm <S_{max} = 300 mm … OK

4.6 DETERMINATION OF SLABS LOADS

4.6.1 One-Way Ribbed Slab.

- **First Floor**

Table 6 : Dead Load First Floor With One-Way Ribbed Slab.

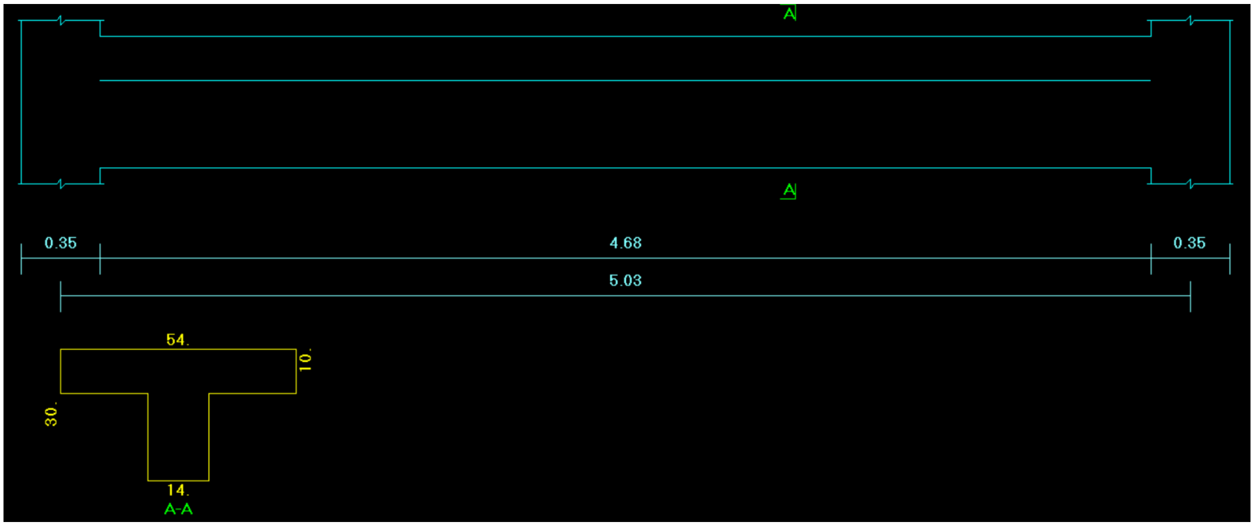
Parts of Rib	Density	D_L (KN/m)
RC. Rib	25	**0.2*0.14*25= 0.7**
RC.Topping	25	**0.1*0.54*25 = 1.35**
Plaster	22	**0.02*0.54*22 = 0.2376**
Block	12	**0.4*0.2*12= 0.96**
Sand Fill	17	**0.07*0.54*17= 0.6426**
Tiles	22	**0.03*0.54*22= 0.3564**
Mortar	22	**0.02*0.54*22 =0.2376**
Partition	-	**1.3*0.54 =0.702**
		∑ = 5.1KN/m

Nominal Total Dead load = **5.1KN/m/rib**

Nominal Total Live load = 5* 0.54= **2.7 KN/m/rib**

4.7 DESIGN OF ONE-WAY RIBBED SLAB

Figure 15: Rib Location



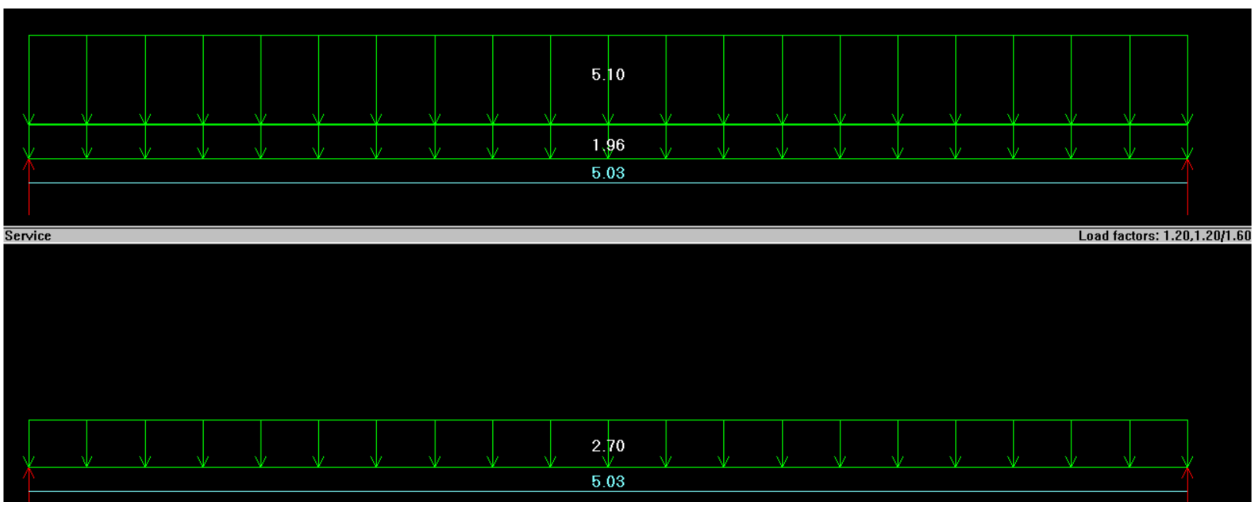


Figure 16: Rib Geometry and loading

- ✓ Material:

Concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel Fy = 420 N/mm^2

- ✓ Section:

b =14cm b_f= 54 cm h =30cm T_f = 10 cm

4.7.1 Design For Flexure:

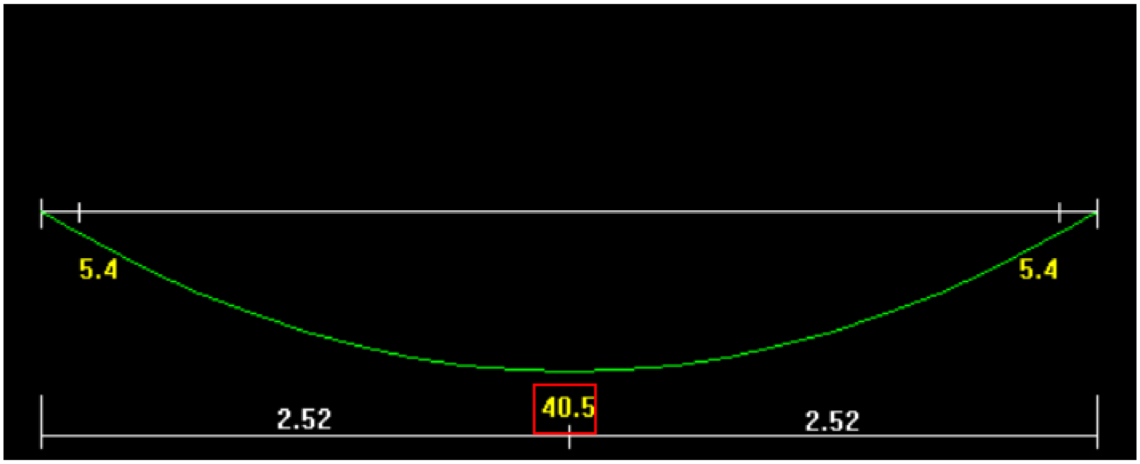


Figure 17: Moment Envelope

- ✓ Factored load:

W_u= (1.2 ×5.1) + (1.6×2.7) = **10.7 KN/m**

- ✓ Moment calculation:

$$M_u = \frac{WL^2}{8} = \frac{10.7 \times 5.03^2}{8} = \mathbf{34.8\ KN.m}$$

- ✓ Design for positive moment (M_u=40.5 KN.m)

Assume bar diameter Ø**10** for main reinforcement.

Assume bar diameter Ø**10** for stirrups.

$$D = 300 - 20 - 10 - \frac{10}{2} = 265 \text{ mm}$$

Check if $a > h_f$:

➡

$\overline{Mn_f} = 0.85 f_{\acute{c}}\, b\, h_f (d - \frac{h_f}{2}) = 0.85 \times 24 \times 540 \times 100 \times (265 - \frac{100}{2}) \times 10^{-6} =$ 236.8KN.m

$\overline{Mn_f} \gg M_u$ …. $\boldsymbol{a < h_f}$ **The section is as rectangular section**

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{34.8 \times 10^6}{0.9 \times 540 \times 265^2}$ 1.01 Mpa

m = $\frac{f_y}{0.85 f_{\acute{c}}} = \frac{420}{0.85 \times 24} = 20.58$

$\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}}) = \frac{1}{20.58}(1 - \sqrt{1 - \frac{2 \times 20.58 \times 1.01}{420}})$ = 0.0024

$A_s = \rho \times b \times d$ = 0.00024× 540 × 265 = 34.344 mm^2

$A_{s_{min}} = 0.25 \times \frac{\sqrt{f_{\acute{c}}}}{f_y} \times b_w \times d \geq \frac{1.4}{f_y} \times b_w \times d$

$A_{s_{min}} = 0.25 \times \frac{\sqrt{24}}{420} \times 140 \times 265 \geq \frac{1.4}{420} \times 140 \times 265$

$A_{s_{min}}$ = *108.18* mm^2 ≤ 123.6 mm^2 **…… Control**

Use 2∅10 with $A_{s_{provid}} = 157.07\ mm^2 > A_{s_{min}} = 123.6\ mm^2$

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

$a = \frac{A_s \times f_y}{0.85 \times f_{\acute{c}} \times b} = \frac{157.07 \times 420}{0.85 \times 24 \times 540}$ = 5.9 mm

$c = \frac{a}{0.85} = \frac{5.9}{0.85}$ =6.94 mm

$\varepsilon_s = 0.003 \left(\frac{d-c}{d}\right) = 0.003\ (\frac{265-6.94}{265})$ = 0.00292> 0.005 **OK.**

4.7.2 Design For Shear:

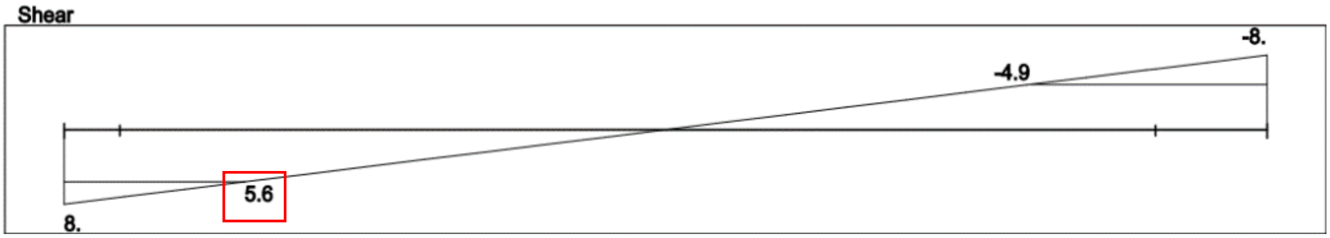


Figure 18: Shear Envelope

✓ **($V_{u,d} = 5.6\ KN$)**

d = 300 − 20 − 10 − $\frac{10}{2}$ = 265 mm

$\emptyset V_c = \emptyset\ \frac{1.1}{6}.\lambda.\sqrt{f_{\acute{c}}}.b_w.d$ = 0.75 . $\frac{1.1}{6}$. 1 . $\sqrt{24}$. 140 . 265 . 10^{-3} = 24.99 KN

$\frac{1}{2}\emptyset V_c = \frac{1}{2} \times 24.99$ = 12.495 KN

Check for Cases: -

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

$V_u = 5.6\ KN < \frac{1}{2}\emptyset V_c = 12.495\ KN$ → **So, no shear reinforcement is provided.**

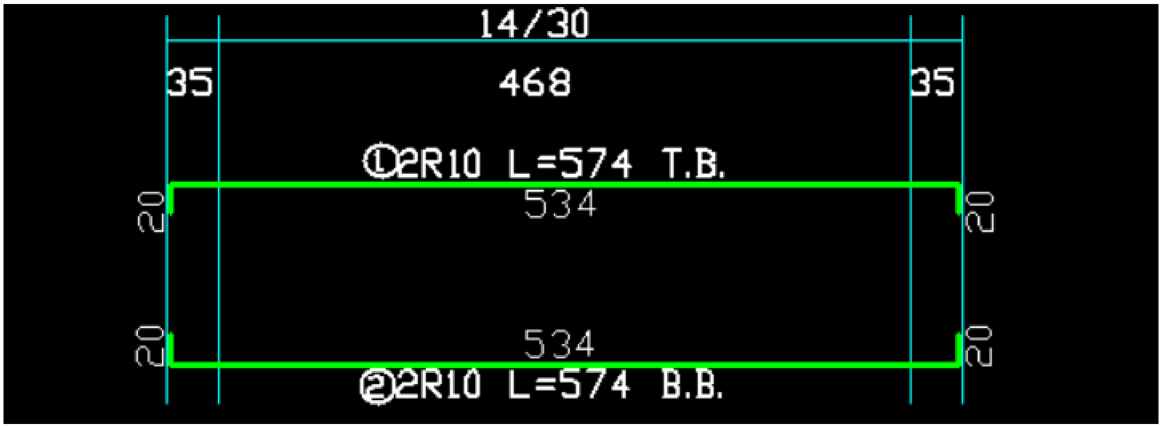


Figure 19 : Reinforcement Of Rib

4.8 DESIGN OF BEAM(B11)

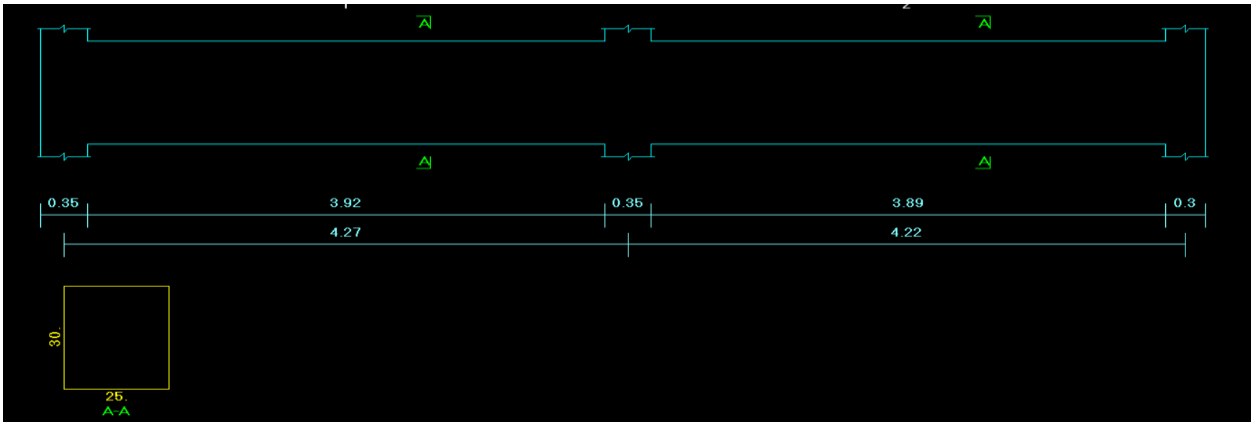


Figure 20: Beam11 Geometry

- ✓ Material:

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel Fy = 420 N/mm^2

- ✓ Section:

B =25 cm

h =30 cm

- ✓ Loads acts on beam B11:

- Own weight of the beam = Sectional Area × γ concrete = 0.25*0.30 *25 = 1.875/2= 0.937kN/m
- Reactions from wall : D.L = 25*3.2*0.25 = 20 kN/m

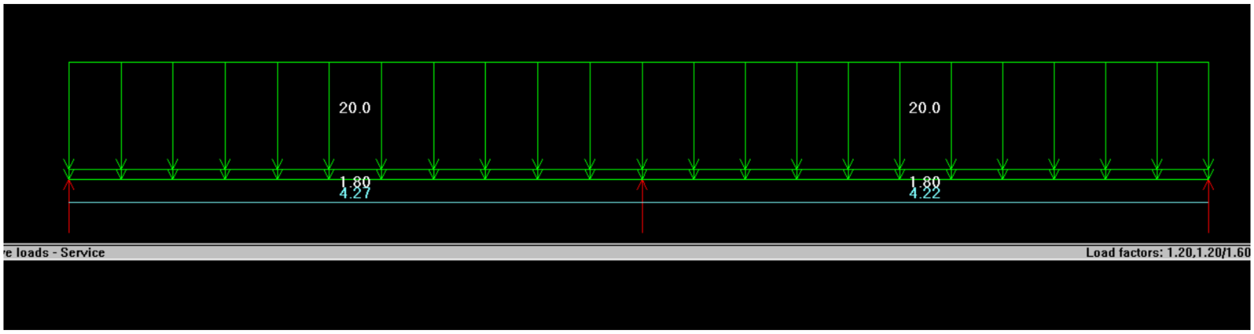


Figure 21: Loads Acts On Beam B11

4.8.1 Design for flexure:

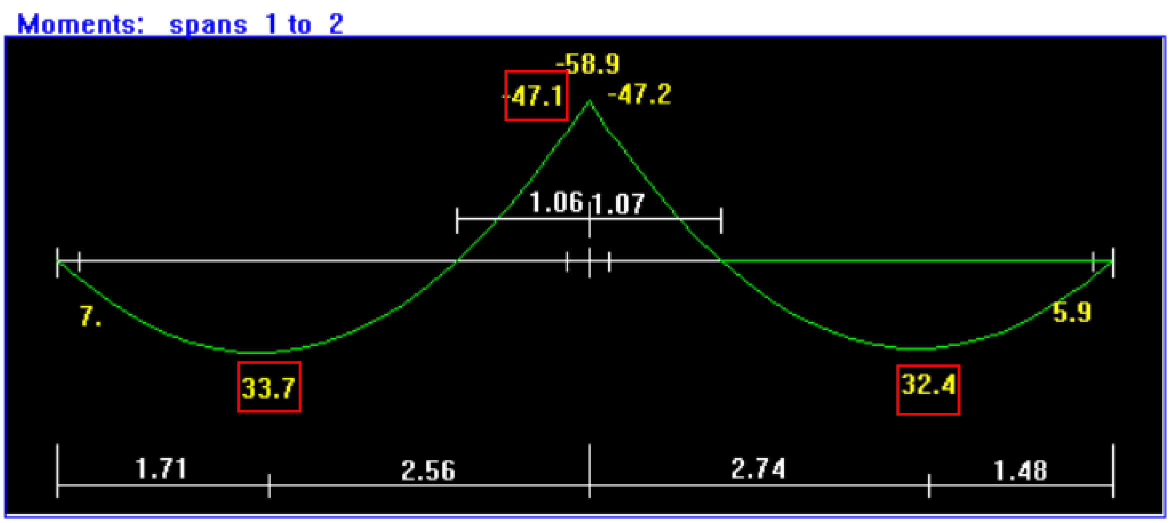


Figure 22: Moment Envelope

✓ ***(Mu_{max} = -47 kN.m)***

Assume bar diameter **Ø16** for main reinforcement.

Assume bar diameter **Ø10** for stirrups.

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

$=300 - 40 - 10 - \frac{16}{2} = 242$ mm

$C_{max} = \frac{3}{7} * d = \frac{3}{7} * 242 = 103.7$ mm.

$a_{max} = \beta_1 * C_{max} = 0.85 * 103.7 = 88.15$ mm.

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

$= 0.85 * 24 * 0.25 * 0.09544 * (0.262 – 0.09544/2) * 10^3$ =104 KN.m

$\varepsilon_s = 0.003 * \frac{d-c}{c} = 0.003 * \frac{242-103.7}{103.7} = 0.004$

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

$\phi Mn_{max} = 0.82 * 104 = 85.28$ KN.m

→ Mu = 47 KN.m < ϕMn_{max} = 85.28 KN.m

∴Singly reinforced concrete section.

✓ Maximum positive moment $Mu^{(+)}$ = 33.7 kN.m

Mn = Mu /ϕ = 33.7 / 0.9 = 37.4 kN.m

m=20.58

$R_n = \frac{M_n}{b*d^2} = \frac{37.4*10^6}{250*(242)^2} = 2.55$ MPa

$\rho = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*2.55*20.58}{420}}\right) = 0.00642$

$A_s = \rho * b * d = 0.00642*250*242 = 388.41\ mm^2$

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

$$= \frac{\sqrt{24}}{4 * 420} * 250 * 242 \ \geq \ \frac{1.4}{420} * 250 * 242$$

$=176\ mm^2 < 201\ mm^2$ …. As, min = $201\ mm^2$

Use 4 ϕ14 …. As= 615.75 mm^2 for bottom reinforcement

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

Tension = Compression

$A_s * Fy = 0.85 * f_c' * b * a$

615.75* 420 = 0.85 * 24 * 250* a

a = 50.7 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{50.7}{0.85}$ = 59.6 mm.

d=300 – 40 – 10 – $\frac{14}{2}$ =243 mm

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{243-59.6}{59.6} * 0.003 = 0.0092 > 0.005$ ∴ **ϕ =0.9 … OK**

✓ Minimum positive moment $Mu^{(+)}$ = 32.4kN.m

Mn = Mu /ϕ = 32.4 / 0.9 = 36 kN.m

m=20.58

$R_n = \frac{M_n}{b*d^2} = \frac{36*10^6}{250*(243)^2}$ = 2.4MPa

$\rho = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*2.4*20.58}{420}}\right) = 0.00609$

$A_s = \rho * b * d = 0.00609*250*243 = 369.9\ mm^2$

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

$$= \frac{\sqrt{24}}{4 * 420} * 250 * 243 \ \geq \ \frac{1.4}{420} * 250 * 243$$

= 177.15mm^2 < 202.2 mm^2 …. As, min = 202.5 mm^2

As, min = 202.5 mm^2 → **Design for minimum reinforcement.**

<u>Use 4 ϕ12</u> …. As= 452.389 mm^2

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

Tension = Compression

A_s * Fy = 0.85 * f_c' * b * a

452.389* 420 = 0.85 * 24 * 250* a

a = 37.25 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{37.25}{0.85}$ = 43.82 mm.

d=300 – 40 – 10 – $\frac{12}{2}$ =244 mm

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{244-43.82}{43.82} * 0.003$ = 0.0137 > 0.005 ∴ **ϕ =0.9 … OK**

- ✓ Maximum Negative moment $Mu^{(-)}$ = -47.1 KN.m

Mn = Mu /ϕ = 47.1 / 0.9 = 52.33 kN.m

D = 242mm → bar diameter Ø16.

m = 20.58

$R_n = \frac{M_n}{b*d^2} = \frac{52.33*10^6}{250*(242)^2}$ =3.57 MPa

$\rho = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*3.57*20.58}{420}}\right)$ = 0.00941

$A_s = \rho$ * b *d =0.00941*250*242 = 569.3 mm^2

Use 4 Φ16 …. As= 804.23 mm² for Top reinforcement.

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

Tension = Compression

A_s * Fy = 0.85 * f_c' * b * a

804.23* 420 = 0.85 * 24 * 250* a

a = 66.23 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{66.23}{0.85}$ = 77.9 mm.

$\varepsilon_s = \frac{d-c}{c} * 0.003 = \frac{242-77.9}{77.9} * 0.003 = 0.0063 > 0.005$ ∴ **ϕ =0.9 … OK**

4.8.2 Design for Shear:

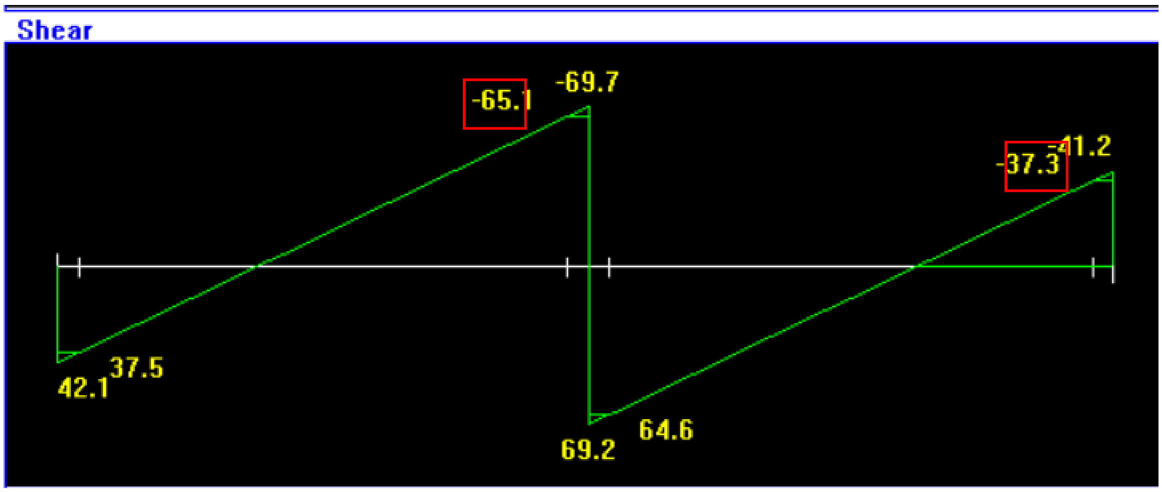


Figure 23: Shear Envelope

✓ $(V_{u,d} = 65.1\ KN)$

$\phi Vc = \phi * \frac{\sqrt{f_c'}}{6} * b * d = 0.75 * \frac{\sqrt{24}}{6} * 250*242 * 10^{-3} = 37$ KN.

$\frac{\phi V_c}{2} = \frac{37}{2} = 18.5$ KN

Check For Cases:-

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

65.1 > 18.5

∴ Case (1) is NOT satisfied

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

18.5 < 65.1 <37

∴ Case (2) is NOT satisfied

Case 3: $\phi V_c < V_u \leq (\phi V_c + \phi Vs_{min})$

$\phi\ Vs_{min} \geq \frac{\phi}{16}\sqrt{f'_c} * b_w * d = \frac{0.75}{16}\sqrt{24} * 0.25 * 0.242 * 10^3 = 13.8$ KN.

$\geq \frac{\phi}{3} * b_w * d = \frac{0.75}{3} * 0.25 * 0.242 * 10^3 = 15.125$ KN …. **Control**.

∴$\phi Vs_{min} = 15.125$ KN.

$\phi V_c + \phi Vs_{min} = 37 + 15.125 = 52.125$ KN.

$\phi V_c < V_u \leq (\phi V_c + \phi Vs_{min})$

52.125 < 65.1 ≤ 52.125 …. **OK**

∴ Case (3) is satisfied → $\left(\frac{Av}{S}\right) = \frac{Vs}{(fy_t * d)}$

$Vs = \left(\frac{Vu}{\phi} - Vc\right)$

$Vs = \left(\frac{65.1}{0.75} - \frac{37}{0.75}\right) = 37.46$ KN

Try 2 Φ 10 = 2 * 78.5 = 157 mm^2.

$\frac{2*78.5}{S} = \frac{37.46 * 10^3}{(420 * 242)}$ → s = 425.98 mm

$s \leq \frac{d}{2} = \frac{242}{2} = 121$ mm …. CONTROL

∴ Use Φ10 @ 10 cm 2Lag.

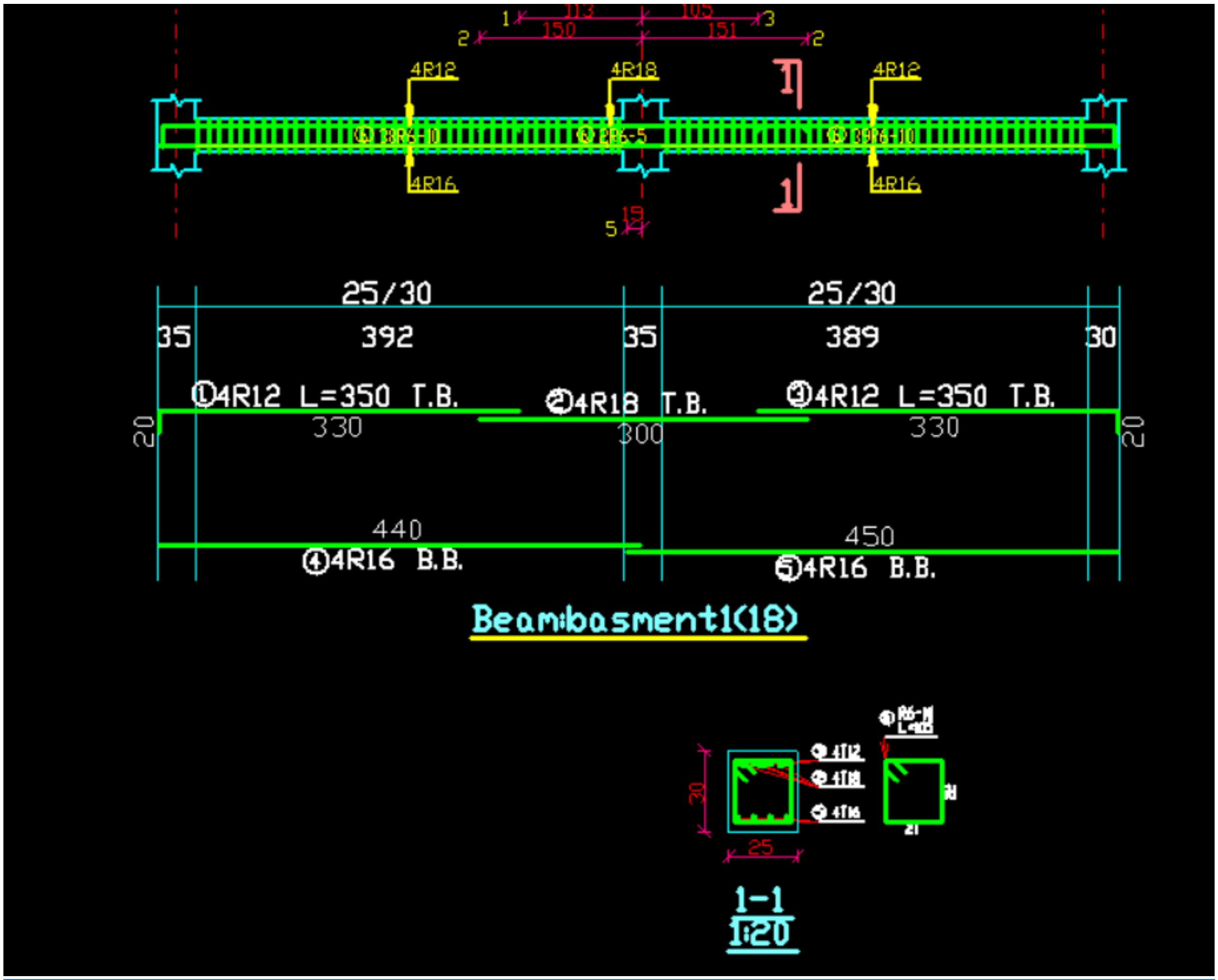


Figure 24 : Reinforcement Of Beam11

4.9 : Design of Stair

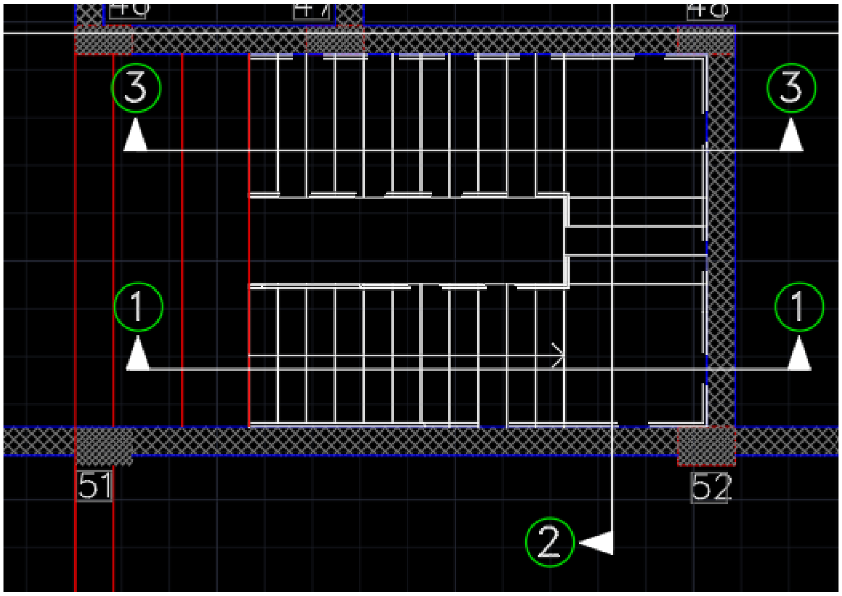


Fig 36: Stair Plan.

✓ **Material :-**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

1- Design of Flight :-

✓ Determination of Thickness:-

h_{min} = L/20

h_{min} = 4.6/20 = 23 cm

Take h = 25cm

The Stair Slope by $\theta = \tan^{-1}(157 / 300) = 27.62$

Dead Load For Flight For 1m Strip:-

Table (4.6): Dead Load Calculation of Flight.

No.	Parts of Flight	Calculation
1	**Tiles**	23*0.03*1*((0.35+0.157)/0.3) = 1.15KN/m
2	**Mortar**	22*0.03*1*((0.3+0.157)/0.3) = 1.0KN/m
3	**Stair**	(25\3)*((0.157*0.3)\2) = 1.96KN/m
4	**R.C**	25*0.25*1 / cos27.62= 7KN/m
5	**Plaster**	22*0.03*1 / cos27.62=0.744KN/m
		Sum = 11.854 KN/m

Dead Load For landing For 1m Strip

No.	Parts of Landing	Calculation
1	**Tiles**	**23*0.03*1= 0.7KN/m**
2	**Mortar**	**22*0.03*1= 0.66KN/m**
4	**R.C**	**25*0.25*1= 6.25KN/m**
5	**Plaster**	**22*0.02*1= 0.44KN/m**
		Sum = 8.01KN/m

Live Load For Flight For 1m Strip = 5*1 =4KN/m

Factored Load For Flight :-

Qu(F) = 1.2 ×11.854 + 1.6×5=22.22KN/m
Qu(L)=1.2*8.01+1.6*5=17.612kn/m

From moment equal zero at a

- ✓ **Design of Shear for Flight :- (RA=44.70 KN)**

VU=44.70-8.81(0.10+.223)=41.85KN

Assume bar diameter ø 14 for main reinforcement

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

$V_c = \frac{1}{6}\sqrt{fc'}b_w \quad \sqrt{24} * 1000 * 223 = 182.1$Kn\M

Φ V_c = 0.75* 182.1 = 136.56 KN > Vu = 41.85 KN …… **No shear reinforcement are required**
2.8 1.15

- ✓ **Design of Bending Moment for Flight :- (Mu=83.875 KN.m)**

MU=44.70(5.9/2)-8.81*1.5*(1.5+2.7/2)-22.22*2.7/2*2.7/4=83.875

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{83.875\times10^6}{0.9\times1000\times223^2} = 1.87\ Mpa$

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

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2\times20.6\times1.87}{420}}\right) = 0.00214$

$A_{s,req}$ = ρ.b.d = 0.0047 ×1000×233 = 1048.1 mm^2/m

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

As_{req} = 1048.1 mm^2>$A_{s,min}$=450 mm^2/m

USE @14 then

N=1048.1/153.9=6.81

Take 7@14/m

Check for Spacing :-

S = 3h = 3*250 = 750mm

S = 380*$(\frac{280}{\frac{2}{3}*420})$ – 2.5*20 = 330

S = 450 mm

S = 330 mm **……… is control**

Use ø14 @ 150 mm , $A_{s,provided}$=1077.3mm^2>$A_{s,required}$ =1048.1mm^2… Ok

Check for strain:-

$a = \frac{A_s . f_y}{0.85 b\, f_c'} = \frac{615.6 \times 420}{0.85 \times 1000 \times 24} = 12.67\ mm$

$c = \frac{a}{\mathcal{B}_1} = \frac{12.67}{0.85} = 14.9\ mm$

$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{223-14.9}{14.9}\right) = 0.041 > 0.005 \quad \dots \dots \boldsymbol{0k}$

✓ Lateral or Secondary Reinforcement For Flight :-

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

Use ø12@ 300 mm, As=452.16mm^2>$A_{s, required}$= 450mm^2… Ok

2- Design of Middle Landing :-

✓ Determination of Thickness:-

hmin = L/20

hmin = 2.6 /20 = 13 cm

Take h = 20 cm

✓ Load Calculation:-

Dead Load for (LA1) Landing For 1m Strip:-

No.	Parts of Landing	Calculation
1	**Tiles**	**23*0.03*1= 0.7KN/m**
2	**Mortar**	**22*0.03*1= 0.66KN/m**
4	**R.C**	**25*0.25*1= 6.25KN/m**
5	**Plaster**	**22*0.02*1= 0.44KN/m**
		Sum = 8.01KN/m

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

Factored Load for Landing:-

W_U = 1.2 ×8.01 + 1.6×5 = 17.61KN/m

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

From moment =zero at A

RA=14.07KN

MU=14.07(2.6/2)-8.81(1.5+.1/2)-17.61*.1/2*.1/4=12.04kn.m

- ✓ **System of Landing:-**

Vu=14.07-8.81(.1+.223)=11.22kn

✓ design of Shear:- (Vu=11.22kn)

Assume bar diameter ø 14 for main reinforcement

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

$V_c = \frac{1}{6}\sqrt{fc'}b_w\ d == \ \frac{1}{6}\sqrt{24} * 1000 * 223 = 182.1$ KN

Φ* V_c = 0.75* 182.1 = 136.6Kn> Vu = 11.22kn **…... No shear reinforcement are required**

✓ Design of Bending Moment :- (Mu=12.04KN.m)

Assume bar diameter ø 14 for main reinforcement

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

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{12.04\times10^6}{0.9\times1000\times223^2} = 0.26Mpa$

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

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2\times20.6\times0.26}{420}}\right) = 0.00182$

$A_{s,req}$ = ρ.b.d = 0.0006×1000×223 = 133.8mm²

$A_{s,min}$ =0.0018*1000*250 = 450mm²

$A_{s,min}$ =450 mm²**……… is control**

Check for Spacing:-

S = 3h = 3*250 =750 mm

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

S = 450 mm

S = 330mm **……… is control**

<u>Use ø14@300 mm</u>

Check for strain:-

a =$\frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{1026.25\times420}{0.85\times1000\times24} = 21.128mm$

c$= \frac{a}{\mathcal{B}_1} = \frac{21.128}{0.85} = 24.85\, mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{223-24.85}{24.85}\right) = 0.024 > 0.005\ \ldots\ldots \boldsymbol{0k}$$

Lateral or Secondary Reinforcement For Landing:-

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

Use ø12 @ 200 mm, As, provided= 452.16 mm^2>$A_{s,\ required}$= 450 mm^2… Ok

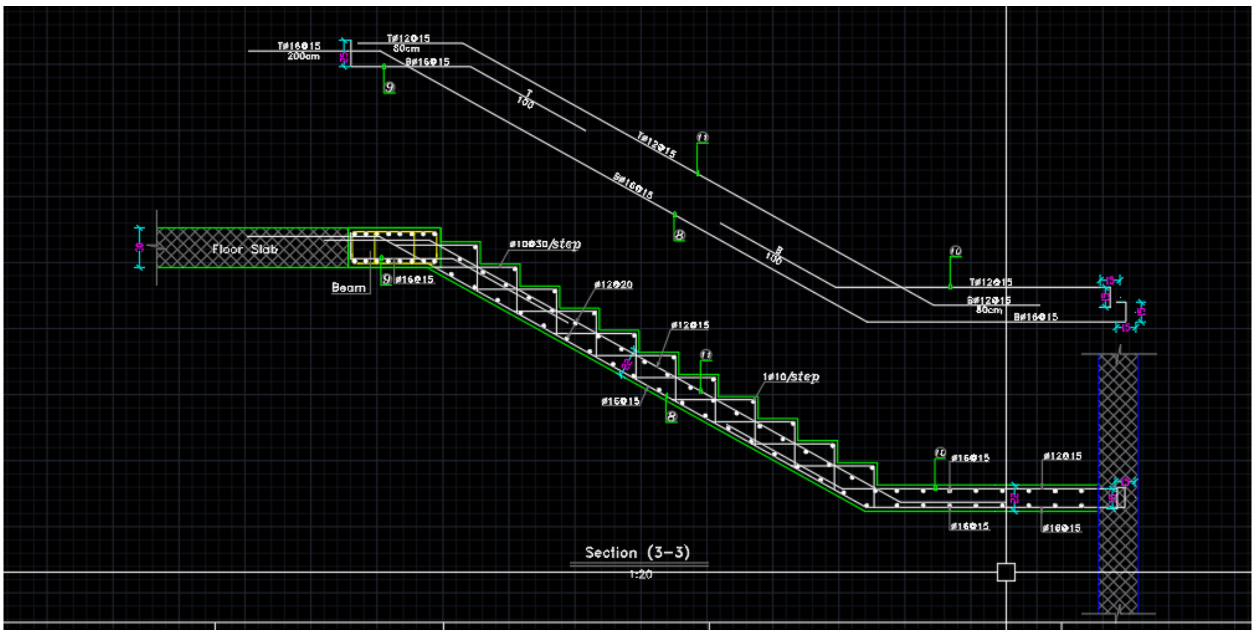


Fig 36: Stair Reinforcement Details

4.10 : Design of Column (C3)

✓ **Material :-**

⇒ concrete B300 $Fc' = 24\ N/mm^2$

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

✓ **Load Calculation:-**

Service Load:-

Dead Load =1506.3KN
Live Load =239.06 KN

Factored Load:-

$P_U = 1.2 \times 1506.3 + 1.6 \times 239.06 = 2190.05KN$

✓ **Dimensions of Column:-**

$Assume\rho g = 0.01$

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

$1034.06 = 0.65 \text{ x } 0.8 \times Ag\{0.85 * 28(1-0.01) + 0.01 * 420\}$

Ag= 214686.2 mm2
Assume Rectangular Section
h = 350 mm
b = 214686.2/350 = 596.35 mm
Select b = 600 mm

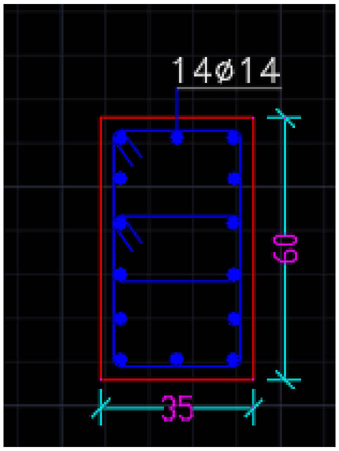


Fig 37 : Column section

✓ Check Slenderness Parameter:-

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

Lu: Actual unsupported (Unbraced) length.

K: effective length factor. According to ACI 318-2002 (10.10.6.3) The effective length factor k, shall be permitted to be taken as 1.0.

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

Lu = 3.55 - 0.7= 2.85 m
M1/M2 =1
K=1 for braced frame.

- **about Y-axis (b= 0.60 m)**

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

$$\frac{1 \times 2.85}{0.3 \times 0.60} = 15.88 < 22$$

Column Is Short About Y-axis

- **about X-axis (h= 0.35m)**

$$\frac{1 \times 2.85}{0.3 \times 0.35} = 27.14 > 22$$

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \quad ....ACI - (10.12.2)$$

Column Is Long About X-axis

✓ **Minimum Eccentricity:-**

$$ey = \frac{Mux}{Pu} = 0$$
$$min\, e\, y = 15 + 0.03 \times h = 15 + 0.03 \times 350 = 25mm = 0.025m$$
$$ey = 0.025m$$

✓ **Magnification Factor:-**

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

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

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

$$EI = 0.4\frac{E_c I_g}{1 + \beta_d}$$
$$E_c = 4700\sqrt{fc'} = 4700 \times \sqrt{24} = 23025.20Mpa$$
$$\beta_d = \frac{1.2DL}{Pu} = \frac{1.2 * (1506.3)}{2190.05} = 0.83 < 1$$
$$I_g = \frac{b \times h^3}{12} = \frac{0.60 \times 0.35^3}{12} = 0.00214m^4$$
$$EI = \frac{0.4 \times 23025.2 \times 0.00214}{1 + 0.83} = 10.7MN.m^2$$

$$P_{cr} = \frac{\pi^2 * 10.7}{(1 * 2.85)^2} = 13MN$$

1

$$\delta_{ns} = \frac{1}{1 - \frac{2190.05}{0.75 * 13)\text{^}2}} = 1.519 \geq 1.0$$

✓ Interaction Diagram:-

$ey = ens_{min}$

$\frac{ey}{h} = \frac{0.025}{0.6} = 0.04$

$\frac{\gamma}{h} = \frac{300 - 2*40 - 2*10 - 16}{300} = 0.613$

From the interaction diagram chart

from chart A9-a for $\frac{\gamma}{h} = 0.6 \rightarrow \rho g = 0.01$

from chart A9-b for $\frac{\gamma}{h} = 0.75 \rightarrow \rho g = 0.01$

then for $\frac{\gamma}{h} = 0.613 \rightarrow \rho g = 0.01$

Select reinforcement

Ast $= \rho g \times Ag = 0.01 \times 350 * 600 = 2100mm^2$

Select 14 $\varphi 14 with$ AS > Ast $= 2100mm^2$.

✓ Design of the Stirrups:-

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

$$spacing \leq 16 \times d_b = 16 \times 2.0 = 25.6\ cm$$
$$spacing \leq 48 \times d_s = 48 \times 1.0 = 48\ cm$$
$$spacing \leq 40\ cm$$

$Use \phi 10 @ 10\ cm$

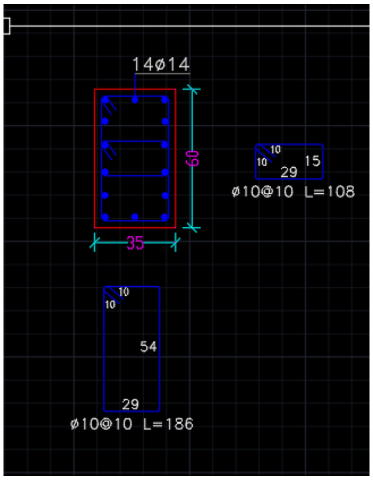


Fig 38: Column Reinforcement Details.

4.11 : Design of Footing (F4)

- ✓ **Material :-**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

✓ Load Calculations

Dead Load =605.06 Kn , Live Load = 97.99 Kn

Total services load = 605.06 + 97.99 = 703.05 Kn

Total Factored load = 1.2*605.06 + 1.6*97. 99 = 882.86 Kn

Column Dimensions (a*b) =35*60 cm

Soil density = 18 Kg/cm3

Allowable Bearing Capacity = 400 Kn/m2

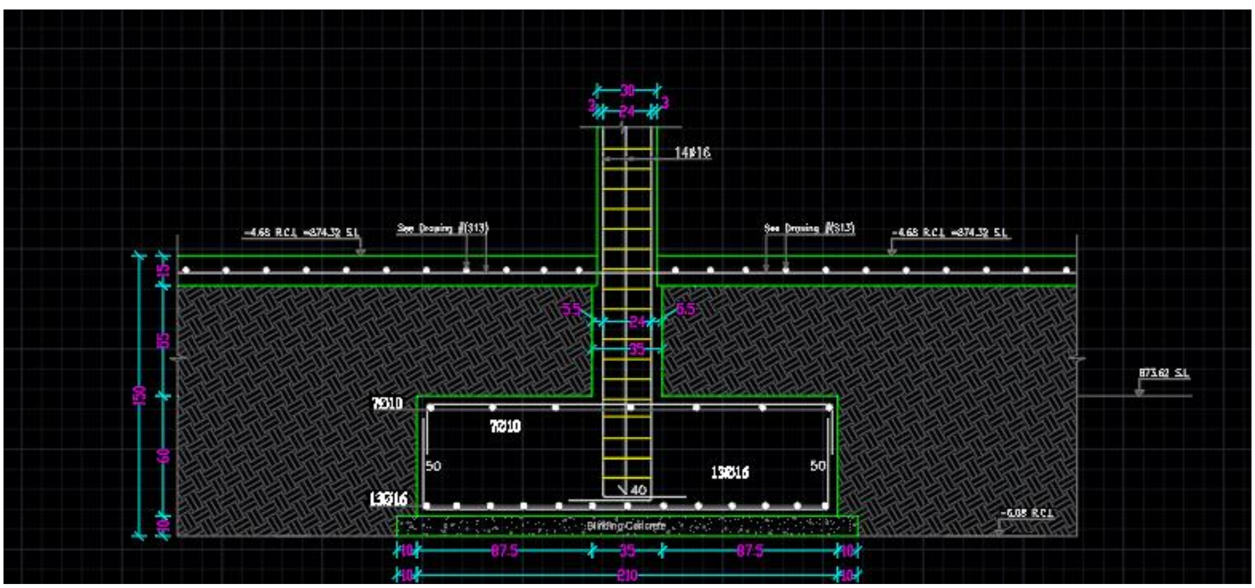


Fig 39: Footing Section.

Assume h = 60cm

$q_{net-allow}$ = 400 –18*0.4 – 25*0.60 = 377.8/m2

✓ Area of Footing :-

$$A = \frac{Pn}{q_{net-allow}} = \frac{703.05}{377.8} = 1.9m^2$$

Assume Square Footing

B required =2 m

Select B = 2m

✓ Bearing Pressure :-

q_u = 882.86/2*2 = 220.71 Kn/m^2

✓ Design of Footing :-

1- Design of One Way Shear Strength :-

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

Assume h = 30cm , bar diameter ø 16 for main reinforcement and 7.5 cm Cover

d = 500– 75 – 16=409 mm

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

Vu = 220.71$* \left(\frac{2-0.3}{2} - 0.409\right) * 2$=194.66kn

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

$$\varphi.Vc = 0.75 * \frac{1}{6} * \sqrt{24} * 2000 * 409 = 500.9Kn$$

$$\varphi.Vc = 500.9KN > Vu = 194.66Kn$$

$\therefore \quad Safe$

2- Design of Two Way Shear Strength :-

$Vu=Pu-FR_b$

$FR_b= q_u*$area of critical section

Vu=220.71-882.86((0.35+0.409)*(0.6+0.409))=102.3Kn

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

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

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

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

Where:-

$\beta_C = \frac{Column\ \ Length\ \ (a)}{Column\ \ Width\ \ (b)} = \frac{35}{60} = 0.6$

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

$$b_o = 2*(40.9+35)+2*(40.9+60) = 353.6CM$$

α_s = 40 for interior column

$$\varphi.V_C = \varphi.\frac{1}{6}\left(1+\frac{2}{\beta_c}\right)\sqrt{f_c{}'}b_o d = \frac{0.75}{6}*\left(1+\frac{2}{0.6}\right)*\sqrt{24}*353.6*409 = 383.8Kn$$

$$\varphi.V_C = \varphi.\frac{1}{12}\left(\frac{\alpha_s}{b_o/d}+2\right)\sqrt{f_c{}'}b_o d = \frac{0.75}{12}*\left(\frac{40*409}{353.6}+2\right)*\sqrt{24}*353.6*409 = 2137Kn$$

$$\varphi.V_C = \varphi.\frac{1}{3}\sqrt{f_c{}'}b_o d = \frac{0.75}{3}*\sqrt{24}*353.6*409 = 177Kn$$

ΦVc =177 Kn>Vu=102.3Kn

3- Design of Bending Moment :-

Critical Section at the Face of Column

Mu = 220.71*2*0.35*0.35/2 =27Kn.m

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{27\times10^6}{0.9\times2000\times409^2} = 0.089 Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.58$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.58}\left(1-\sqrt{1-\frac{2\times20.58\times0.089}{420}}\right) = 0.000212$

$A_{s,req}$ = ρ.b.d = 0.0002×2000×409 = 163.6 mm^2

$A_{s,min}$ = 0.0018*2000*600= 2160 mm^2

$A_{s,req}$ <$A_{s,min}$ =1080 mm^2

As,min =2160……… is control

Check for Spacing:-

S = 3h = 3*60 = 180cm

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

S = 45 cm **……… is control**

<u>Use 13ø16in Both Direction</u>

Check for strain:-

a =$\frac{A_s.f_y}{0.85b\, f_c'} = \frac{2160*420}{0.85\times2000\times24} = 22\ mm$

c = $\frac{a}{\mathcal{B}_1} = \frac{43}{0.85} = 26\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{409-26}{26}\right) = 0.044 > 0.005\ \ldots\ldots \mathbf{0k}$$

4- Design of Dowels :-

Load Transfer In Footing:-

$$\Phi Pn.b = \Phi(0.85\,fc' A_1 \times \sqrt{\frac{A_2}{A_1}})$$

$A_1 = 60 * 35 = 0.21\ m^2$

$A_2 = 2 * 2 = 4\ m^2$

$$\sqrt{\frac{A_2}{A_1}} = \sqrt{\frac{1.44}{0.21}} = 2.6 > 2 \ldots\ldots\ldots\ldots\ldots \sqrt{\frac{A_2}{A_1}} = 2$$

$$\Phi Pn.b = 0.65 \times (0.85 \times 24 \times 210 \times 2) = 5569.2Kn$$

$$\Phi Pn = 5569.2 > Pu = 2206.05 \ldots\ldots\ldots\ldots ok$$

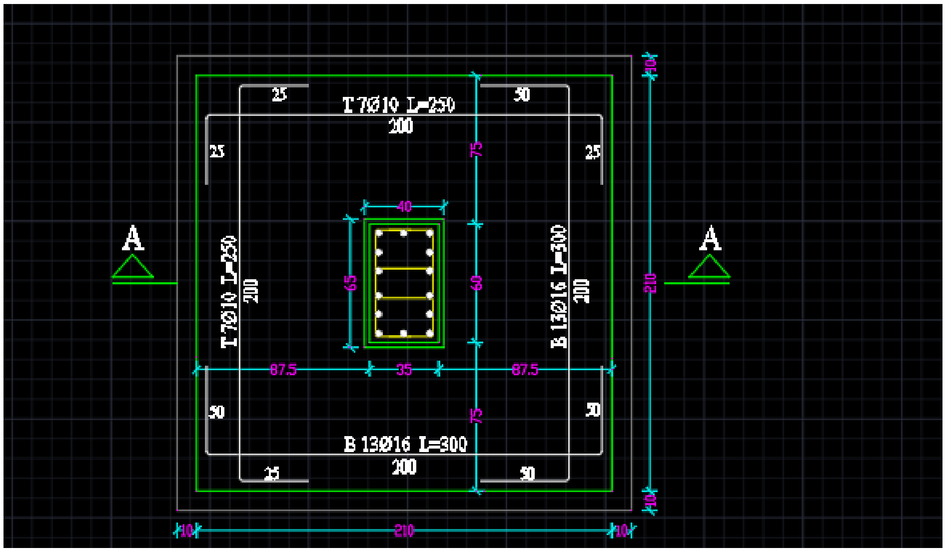


Fig 40:Foot Reinforcement Details.

4.12 : Design of Shear Wall (SW,1)

✓ **Material and Sections: - (From Shear Wall 1)**

⇒ concrete B300 Fc' = 24 N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

⇒ Shear Wall Thickness h = 30 cm

⇒ Shear Wall Width Lw = 6.15 m

⇒ Shear Wall Height Hw = 14.56 m

✓ **Design of Horizontal Reinforcement: -**

$$\sum Fx = Vu = 1700\ KN$$

The critical Section is the smaller of:

$$\frac{lw}{2} = \frac{6.15}{2} = 3.075m \ldots.Control$$
$$\frac{hw}{2} = \frac{14.56}{2} = 7.28m$$
$$storyheigh(Hw) = 3.64m.$$

$$d = 0.8 \times Lw = 0.8 \times 6.15 = 4.92m$$

$$\emptyset V_{nmax} = \emptyset \frac{5}{6}\sqrt{f_c{}'}hd$$
$$= 0.75 * 0.833 * \sqrt{24} * 300 * 2000 \ = 1836.38\ KN > V_u \ = 1700KN$$

V_c is the smallest of:

$$1 - \ V_c = \tfrac{1}{6}\sqrt{f_c{}'}hd = \tfrac{1}{6}\sqrt{24} * 300 * 2000 = 489.87KN$$
$$2 - \ V_c = 0.27\sqrt{f_c{}'}hd + \frac{N_u d}{4l_w} = 0.27\sqrt{24} * 300 * 2000 + 0 = 793.63KN$$

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

$= \left[0.05\sqrt{24} + \frac{6.15\left(0.1\sqrt{24}+0\right)}{3.092}\right] 300 * 2000 = 384.63\ KN$ …….. Control

$M_u = 4785.416\ KN.m$

$$\frac{M_u}{V_u} - \frac{l_w}{2} = \frac{4785.416}{1700} - \frac{6.15}{2} = 3.093$$

Vc =$384.63KN$

Vu = 1700KN > $\frac{1}{2}$ * 0.75*384.63 =144.24 KN **Needs reinforcement**

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

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

Vs=vu/$\emptyset - vc$

Vs=1700/0.75-384.63= 1882.03 KN

.

- Maximum spacing is the least of:

$\frac{Lw}{5} = \frac{6150}{5}$ = 1230 mm

3*h = 3*300 = 900 mm

450 mm ……. Control

Take ρ = 0.0025

Try Ø12 ($A_S = 78.5\ mm^2$) two layers

$\rho = \frac{A_{vh}}{hS_h} = \frac{2*113.1}{300S_h}$ =0.0025

S_h= 301.6mm

→ use Ø12@150 mm in tow layer

✓ Design of Vertical Reinforcement: -

$\frac{A_{vv}}{S_v} = \left[0.0025 + 0.5\left(2.5 - \frac{h_w}{Lw}\right)\left(\frac{A_{vh}}{S_h*h} - 0.0025\right)\right]*300$

$\frac{A_{vv}}{S_v} = \left[0.0025 + \left(0.5\left(2.5 - \frac{14.5}{6.15}\right)\left(\frac{307.8}{150*300} - 0.0025\right)\right)\right]*300$

$\frac{A_{vv}}{S_v} = 0.935$

Try Ø14 ($A_S = 153.9\, mm^2$) two layers

$\frac{2 * 153.9}{S_v} = 0.193$

S_v= 1594.8 mm

- Maximum spacing is the least of:

$\frac{Lw}{3} = \frac{2500}{3}$ = 833.33 mm

3*h = 3*300 = 900mm

450 mm ……. Control

→ use Ø14@200 mm in tow layer

✓ Design of Bending Moment: -

$A_{st} = \left(\frac{2500}{200}\right) * 2 * 113.1 = 2827.5\, mm^2$

$w = \left(\frac{A_{st}}{L_w h}\right)\frac{f_y}{f_c'} = \left(\frac{2827.5}{2500 * 300}\right)\frac{420}{24} = 0.066$

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

$\frac{C}{l_w} = \frac{w + \alpha}{2w + 0.85\beta_1} = \frac{0.066 + 0}{2 * 0.066 + 0.85 * 0.85} = 0.077$

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

$$= 0.9[0.5*2827.5*420*2500(1+0)(1-0.077)] = 1233.12\ KN \geqq 414.6889\ KN.m$$

Mub = Mu-ØMn = 414.6889 - 1233.12 = −818.4311 KN.m

X≥ $\frac{lw}{600*\frac{\Delta h}{hw}}$=$\frac{2500}{600*3.093}$=1.35 mm

Lb≥ $\frac{X}{2} = 0.675\ mm$

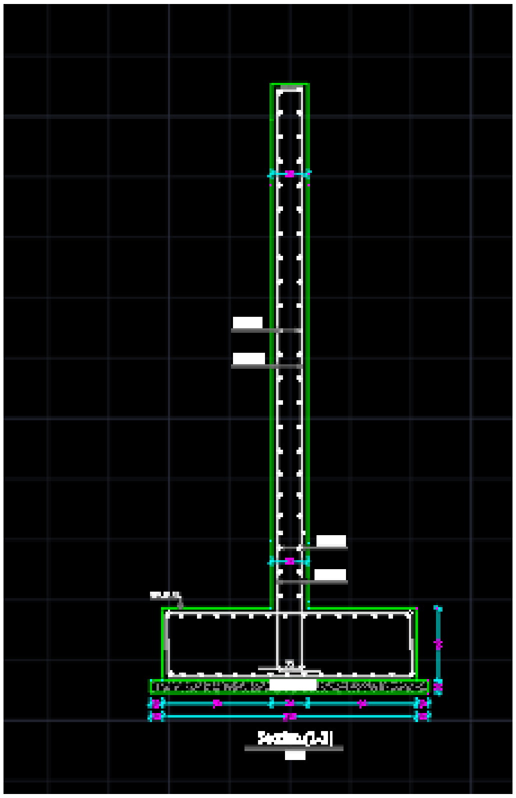


Fig 40: Footing Reinforcement Details.

CHAPTER 5
" REFERENCES "

5.1 REFERENCES

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تم بحمد الله