Palestine Polytechnic University

College of Engineering

Civil Engineering

Graduation Project

Structural Design for

"Entertainment building" In Hebron City

Project Team

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Supervisor:

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This project submitted to the College of Engineering in partial fulfillment of requirements of the Bachelor degree of Civil Engineering

H e b r on – P a l e s t in e

DEDICATION

To Mom and Dad, family and friends. To our competitors and supporters. To caffeine and sugar, our companions through long nights. To everyone that has made us the persons who we are. Also, we dedicate this simple work for our teachers who tries to simplify the engineer science for us.

Acknowledgement

Thanks be to Allah for this guidance and providence! we would like to take the opportunity to whole heartedly thank to everyone who supported us we especially thank: Palestine Polytechnic University, Engineering Collage, Civil Engineering Department, including all members of the helpful and reverend staff. All lecturers at the university. we would especially like to thank Dr.Maher Amro, who extended Great effort on the project. Everyone who helped in the project and got great help.

CHAPTER (1):

Introduction:

Development in the world is an endless matter. Every day and every hour a new development occurs. Buildings, streets, cities, airports, dams and other facilities are among the things that have developed in this world, how did they develop, how are they built, what are the foundations used in construction and what are its uses, all these questions will be answered by one person, the civil engineer.

1.1 Overview:

Our project is a recreational building located in the Namera area of Hebron. This project was chosen to complete the graduation project in the field of Civil Engineering / Building Engineering. In this project, all the structural requirements for the three stores building will be found so that it can carry the loads on.

1.3 The aim of the project:

The objective of this project is to make the structural design for all the structural elements in the building, including knots, bridges, columns, foundations, and others.

1.4 Work Procedure:

To achieve the objectives of the project following steps were followed:

1 Architectural study in which the site, building plans, and elevations were been studied.

2 Structural planning of the building, in which the location of columns, beams, and shear walls was determined to fit with architectural design.

3 Structural study in which all structural members were identified and different loads were been estimated.

4 Starting analysis and design for elements according to the ACI Code.

5 Preparation of Structural drawings of all existing elements in the building.

1.5 The scope of the Project:

Project contains several chapters are detailed as follows:

- Chapter 1: A general introduction to the project.
- Chapter 2: Includes description of architectural project.
- Chapter 3: Structural Description of the project.
- Chapter 4: Analysis and structural design.

1.6 programs we will use:

1. Microsoft Office: text writing and project output.
2. AUTOCAD 2020: for detailed drawings of structural elements.
3. ATIR81: Structural design and analysis of structural elements.
4. Etabs17:design of structural elements.
5. Safe80: design of slabs & footings.

CHAPTER (2):

Architectural description:

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.

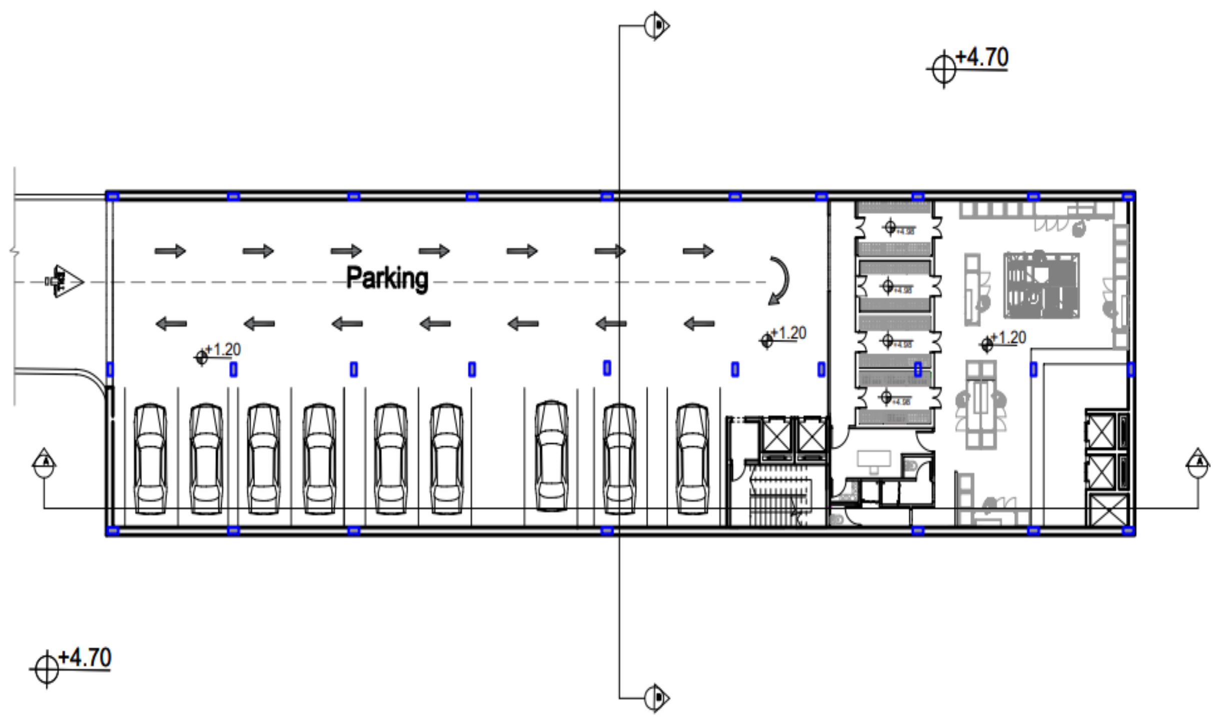
Architectural study that must precede the start of architectural design must be easy to handle and understand different events that it contains building and functional relations among them, and the nature of the association movement and using these parts, and other things of importance that give a clear picture of the project and therefore it will be possible to locate the columns, shear walls and other structural elements to suit architectural design.

2.2 General identification of the project:

This building is a recreational building consisting of 3 floors, the area of each floor is 655 square meters, located in the Namera area in Hebron, on a land area of 3442 square meters. The basement floor, which is a parking lot in addition to rooms for refrigerators for restaurants, while the ground floor contains juice stores and a gym, and the first floor contains restaurants and games for children.

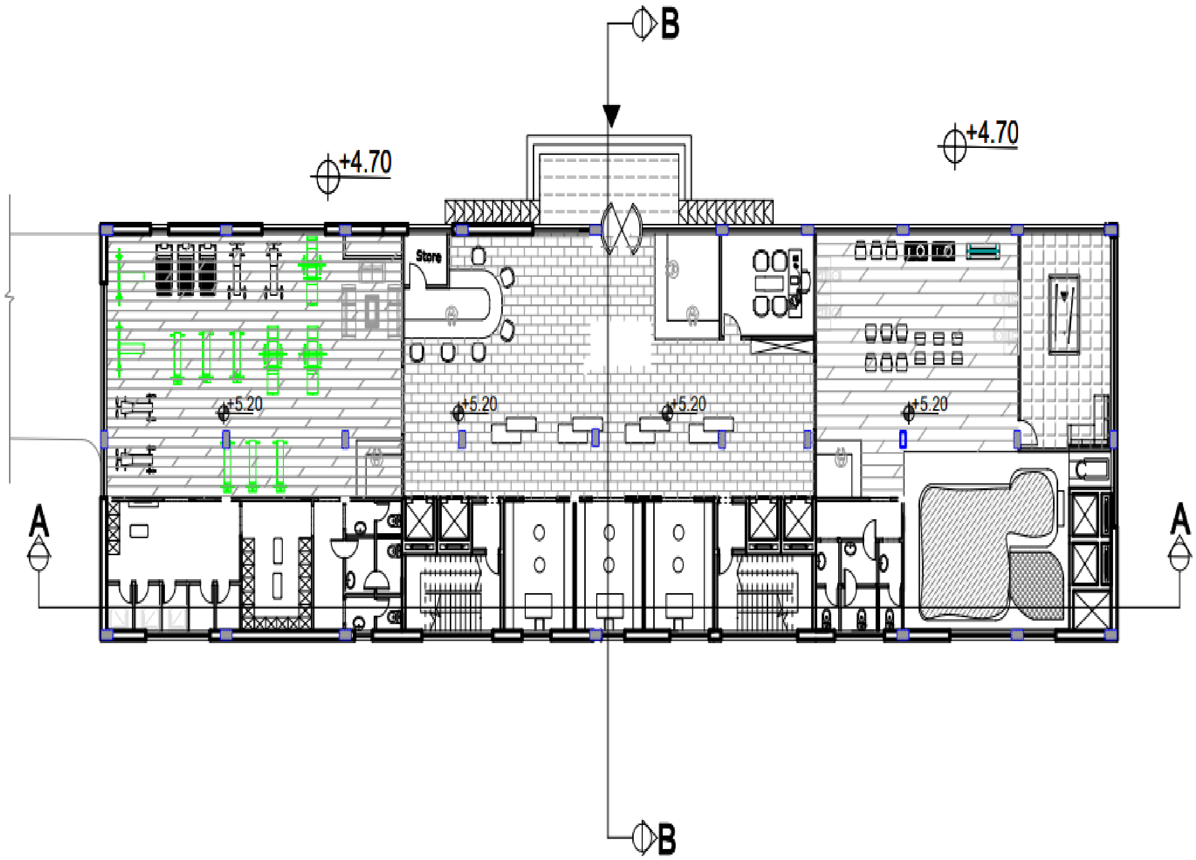
2.3 Basement floor:

The area of this floor is 655 m^2 It contains a car park in addition to refrigerator rooms for restaurants:



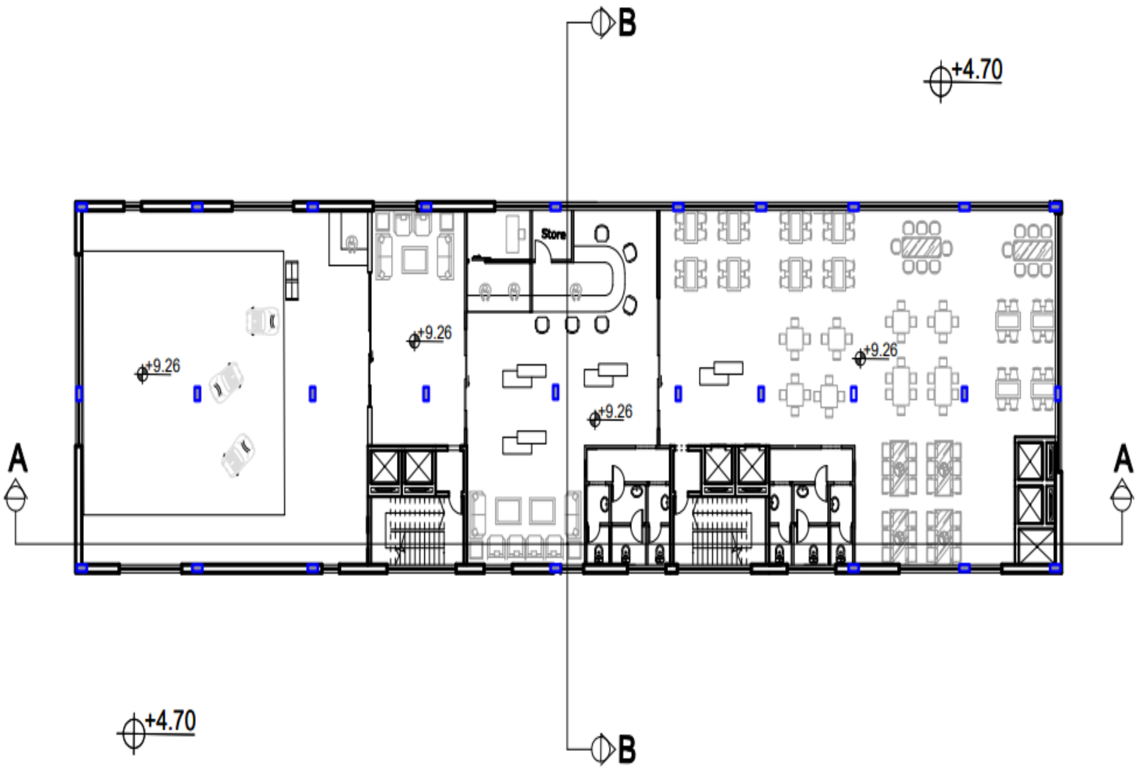
2.4 Ground floor:

The area of this floor is 655 m^2, It contains juice stores in addition to a gym:



2.5 First floor:

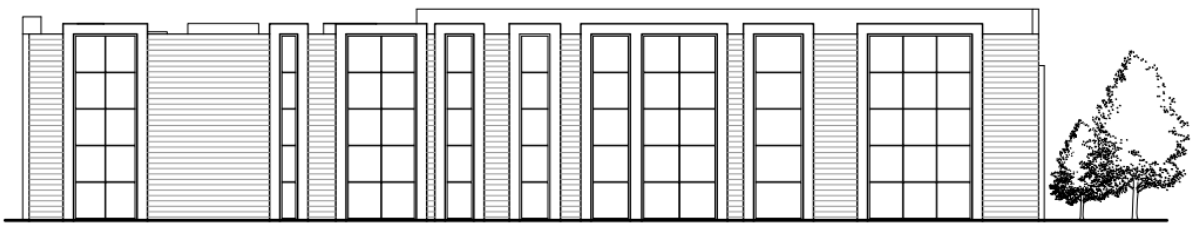
The area of this floor is 655 m^2, It contains restaurants in addition to games for children:



2.6 East elevation:

East Elevation

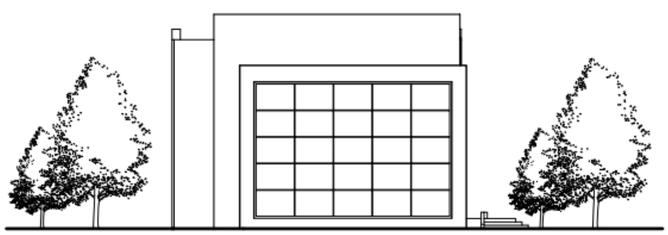
Scale 1/100



2.7 North elevation:

North Elevation

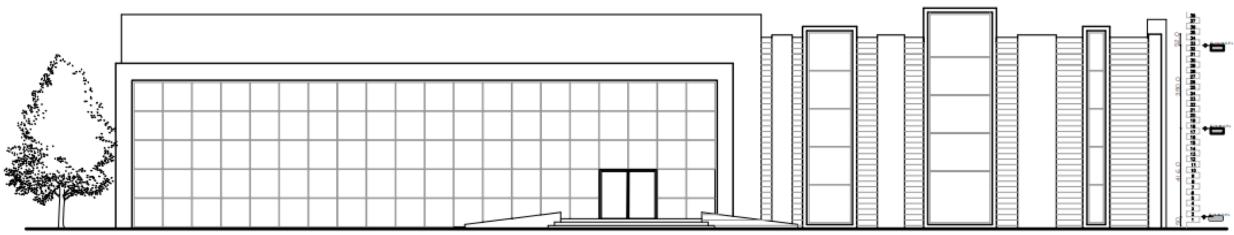
Scale 1/100



2.8 West elevation:

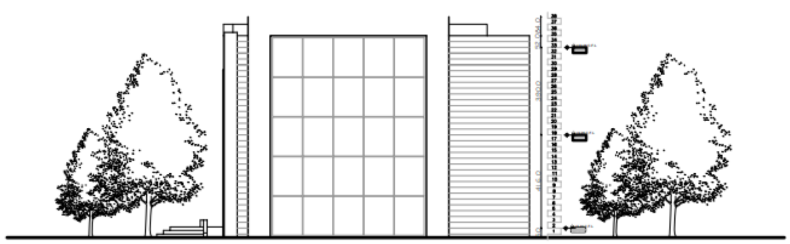
Wast Elevation

Scale 1/100

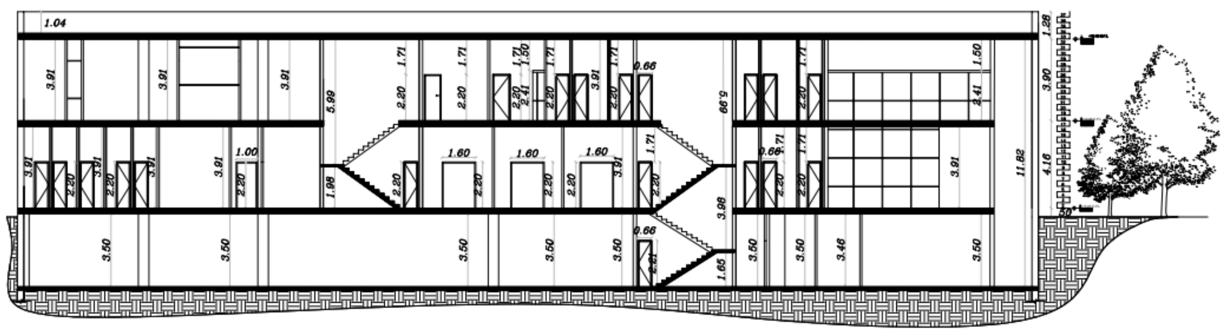


2.9 South elevation:

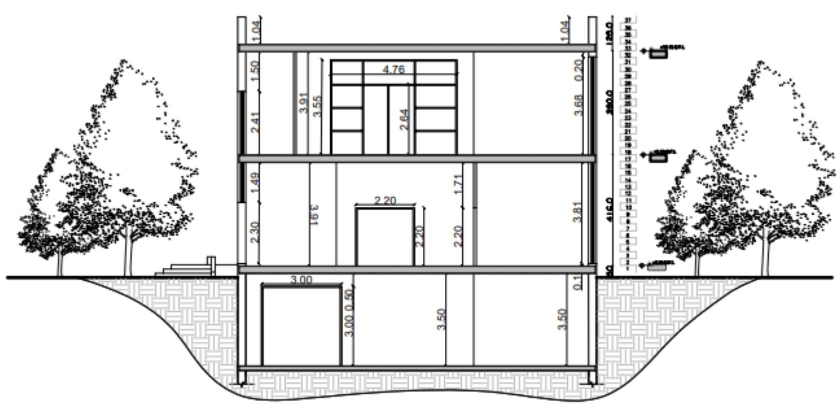
South Elevation
Scale 1/100



2.10 Section A:A :



2.11 Section B:B :



CHAPTER (3)

Structural description

3.1 Introduction:

After completion of the architectural study of the building, A study of the structural elements was done to determine the optimal structural system for the building to make the best design of all structural elements.

After the human known the structural design, it was necessary to evolve its structural design to provide two basic factors, namely safety and economy.

Therefore, it is necessary to identify the structural structures that make up the project in order to choose the best and optimal elements so as to achieve safety and economy,

in addition to not to conflict with the architectural plans laid down, and the purpose of the process of structural design is to ensure that the necessary operating advantages, while preserving as much as possible On the economic factor.

So In this chapter, the structural elements of the project will be identified and explained.

3.2 The Aim of the Structural Design:

The main purpose of structural design is to make a safe, economic, and serviceable design, so in designing a structure the following objectives must be taken into consideration:

1- **Safety**: The structure should be able to carry all expected loads safely
2- **Durability:** The structure should last for a reasonable period of time.
3- **Stability:** to prevent overturning, sliding, or buckling of the structure.
4- **Strength:** to resist safely the stresses induced by the loads in the various structural members.
5- **Serviceability**: To ensure satisfactory performance under service load conditions.

3.3 Scientific Tests

Before the structural study of any building, there is the work of geotechnical studies of the site, which means all work related to exploring the site and studying soil, rocks, and groundwater, then analyzing information and translating it to predict the way the soil behaves when building on it, and the most important thing is to obtaining soil durability (Bearing Capacity) required to design the building's foundations.

3.4 Loads Acting on the Building:

3.4.1 dead loads

They are the stable and constant loads with the stability of the origin resulting from gravity and are divided into two parts: the loads that come of the structural elements for finishing the building, and the loads coming from the weights of the structural elements themselves, such as slabs beams, columns, foundations, etc., and these loads are known through the dimensions and densities of the materials used in structural elements.

3.4.2 live load

Live loads are those loads produced by the use and occupancy of the building

3.4.3 wind load

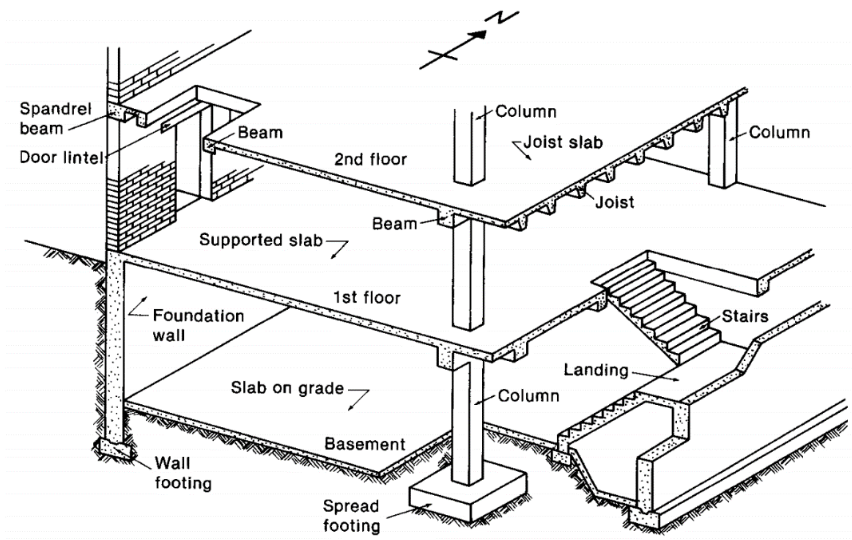
They are horizontal forces that affect the building and their effect appears in tall buildings.

3.4.4 sesimic load

horizontal and vertical forces that generate torque, and can be resisted by using shear walls designed with thicknesses and sufficient reinforcement to ensure the safety of the building.

3.5 Structural Elements of the Building

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



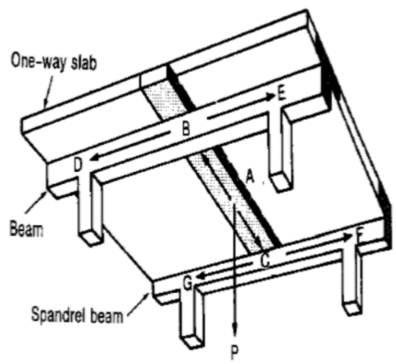
3.5.1 Slabs

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

There are many different Structural systems of reinforced concrete slabs, including the following:

3.5.1.1 Solid slab (one or two way)

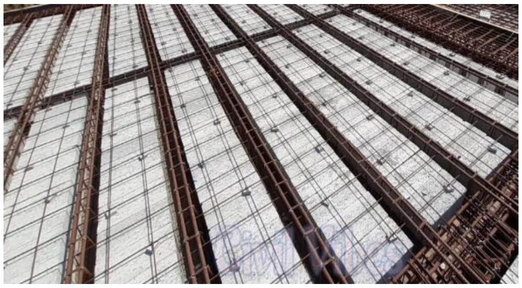
Solid Slabs are fully customizable concrete slabs of varying width, length, and thickness. They can be used in a variety of applications such as bridges, piers, and building floors. It is known that solid slabs should be supported by drop beams.



3.5.1.2 Ribbed slab (one or two way)

It's the most common system used in Palestine. They are made up of wide band beams running between columns with narrow ribs spanning the orthogonal direction. Normally the ribs and the beams are the same depth. A thin topping slab completes the system. It can be designed to carry loads either in one direction only, or in two directions.

Figures (3-5),(3-6) describe one-way and two-way ribbed slabs respectively.



Figure(3- 3): One way ribbed slab

Figure(3- 4):Two way ribbed slab

3.5.2 Beams

They are basic structural elements in transferring loads from slabs to the columns, and they are of two types, hidden inside the slab and Dropped Beams that emerge from the slab from the bottom.

Figure(3- 5):Beams

3.5.3 Columns

Columns are the main member in transporting loads from slabs and beams to foundations, and as such, they are a necessary structural component for conveying loads and building stability. Therefore, they must be designed to be able to carry and distribute the loads on them.

Figure(3- 6):Different types of Columns

3.5.4 Shear walls

They are structural load-bearing elements that resist vertical and horizontal forces located on them and are mainly used to resist horizontal loads such as wind and earthquake forces.

These walls are armed with two layers of steel to increase their efficiency to resist the horizontal forces. The two directions taking into consideration that the distance between the center of resistance formed by the shear walls in each direction and the center of gravity of the building is minimal. And that these walls are sufficient to prevent or reduce the generation of torque waves and their effects on the walls of the building resisting horizontal forces.

3.5.5 Foundations

Loads act on foundations came from the loads on the slabs which transferred to the beams, then to columns, and finally to foundations. and these loads are the design loads for the foundations.

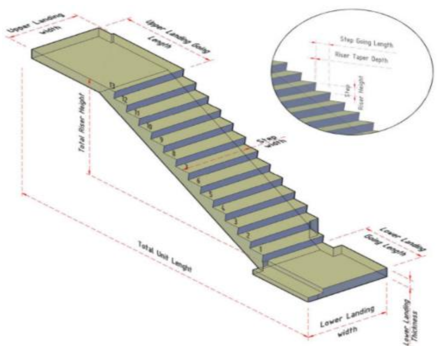
There a many types of foundations that can be used in each project it depends on the type of loads and the nature of the soi in the site.

Figure(3- 7): Isolated Footing

3.5.6 Stairs

Stairs must be provided in almost all buildings. It consists of rises, runs, and landings. The total steps and landings are called a staircase.

There are different types of stairs, which depend mainly on the type and function of the building and the architectural requirements.



Figure(3- 8): Stairs

CHAPTER 4

STRUCTURAL ANALYSIS AND DESIGN (By Calculations)

4.1 Introduction :

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

A bond forms between the steel and the concrete, and stresses can be transferred between both components. The design strength provided by a member flexure, and load, and shear is taken as the nominal strength calculated in accordance with the requirements and assumptions of ACI-code.

NOTE:

*****Concrete B300, {fc'= 24 MPa for rectangular and T section}.

*The specified yield strength of the reinforcement {fy = 420MPa}.

4.2 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:

$$q_u = 1.2DL + 1.6L$$

ACI – 318 - 14 (9.2.1)

4.3 Determination of slab thickness

Determination of Thickness for One Way Ribbed Slab:

According to ACI-Code-318-14, the minimum thickness of no prestressed beams or one-way slabs unless deflections are computed as follow:

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

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

= 683/21 = **32.52 cm**

Select Slab thickness **h= 35cm** with **block 27 cm** & **Topping 8cm.**

Load calculations:

One-way ribbed slab:

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

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

Parts of Rib	Density	Calculation
RC. Rib	**25**	**0.27*0.14*25= 0.945 KN/m**
Top Slab	**25**	**0.08*0.54*25 = 1.08 KN/m.**
Plaster	**22**	**0.03*0.54*22 = 0.3564 KN/m.**
Block	**10**	**0.4*0.27*10= 1.08 KN/m**
Sand Fill	**17**	**0.07*0.54*17= 0.6426 KN/m**
Tile	**23**	**0.03*0.54*23 = 0.3726KN/m**
Mortar	**22**	**0.03*0.54*22 =0.3564 KN/m.**
partition	**-**	**2.3*0.54 =1.242 KN/m**

Nominal Total Dead load = **6.075 KN/m** of rib

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

4.4 Design of topping

When designing the upper part of the slab (select one meter wide of strip) is taken to calculate the load on it. The calculation of the total dead load for the topping is shown below

Table (4 – 2) Calculation of the total dead load on topping

No.	Material	Calculation
1	**Tile**	**0.03*23*1= 0.69 KN/m**
2	**mortar**	**0.03*22*1= 0.66 KN/m**

3	**Coarse sand**	**0.07*17*1= 1.19 KN/m**
4	**topping**	**0.08*25*1 = 2.0 KN/m**
5	**Interior partitions**	**2.3 *1 =2.3 KN/m**
Sum		**6.84 KN/m**

W_u = 1.2 DL + 1.6 LL

= 1.2 * 6.84+ 1.6 * 5 = 16.208 KN/m^2. (Total Factored Load)

$M_u = \frac{W_u * l^2}{12} = 0.216$ KN/m

Vu=$\frac{W_u * l}{2} = \frac{16.208*0.4}{2}$=3.242

Ø Mn≥ Mu, where Ø=0.55 (for plain concrete)

Mn=0.42$\boldsymbol{\lambda}\sqrt{\boldsymbol{fc}'}$ Sm

Where Sm for rectangular section of the slab:

Sm =$\frac{b*h^2}{6}=\frac{1000*80^2}{6}$=1066666.67mm3

Mn = 0.42 $\boldsymbol{\lambda}\sqrt{fc'}$ Sm = 0.42 × 1 × √24 × 1066666.67 × 10^{-6} = 2.19 kN.m

Ø Mn = 0.55 × 2.19 = 1.207 KN.m >> Mu= 0.216kN.m

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

According to ACI 7.12.2.1, $\rho_{shrinkage}$=0.0018

$As = \rho bh$ = 0.0018 × 1000 × 80 = 144 $mm2\ for\ 1m\ strip$

Try bars Ø8 with As = 50.27mm2.

Bar numbers n=(As /As,Ø8)= (144 /50.27)=2.87

Take 3Ø8/m with As = 150.8mm2 /m strip or Ø8@ 300mm in both directions.

Choosing (S) is the smallest of:

1. 3h = 3 × 80 = 240 mm >>> Controlled

ACI (10.5.4)

2. 450mm

3. S = 380(280 /fs) − 2.5Cc = 380 (280 /0.6667*420) − 2.5 .20 = 330mm

ACI (10.6.4)

4. S ≤ 300 (280/fs) = 300 mm

So, Take Ø 8 @ 200 mm in both direction, S = 200 mm

4.5 Design of one way Ribbed slab R1

Material: -

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

Section: -

b =14 cm b_f=54 cm

h =35 cm T_f=8 cm

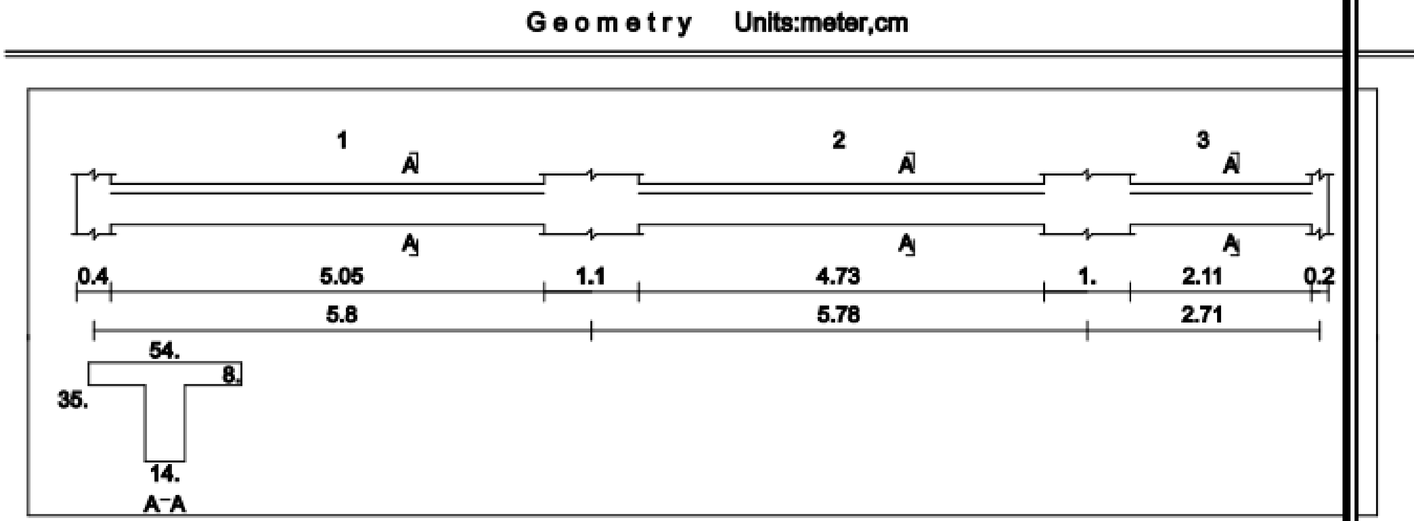


Figure (4-1): Rib geometry.

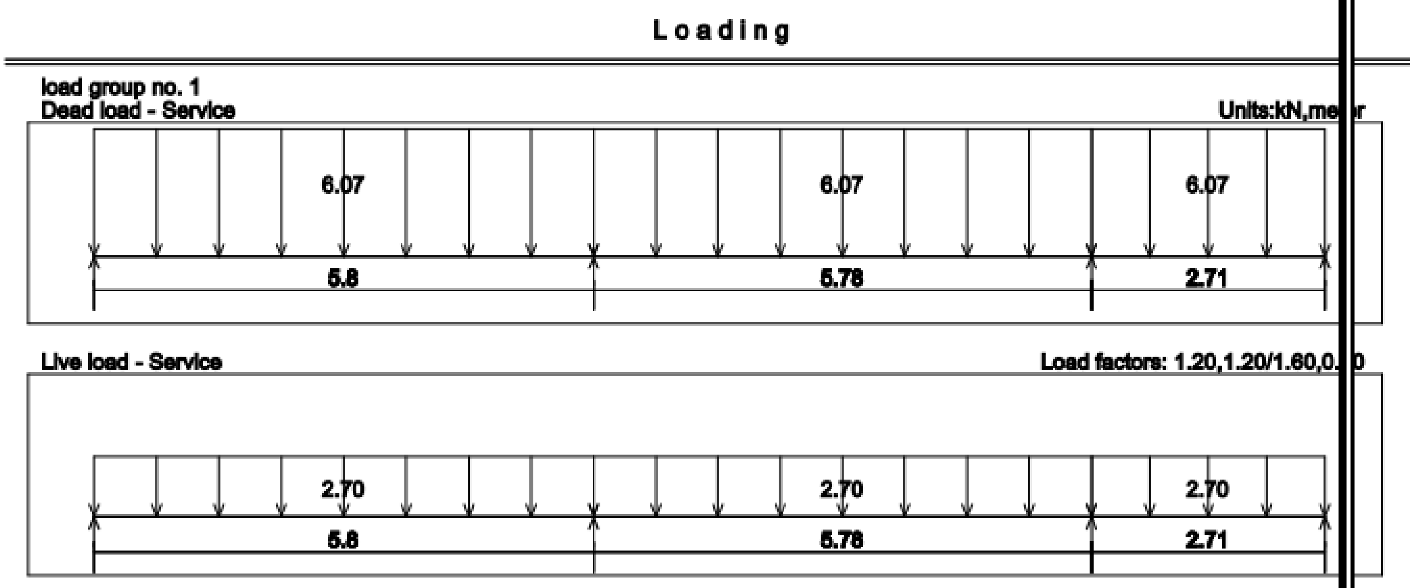


Figure (4-2): loading of rib (1)

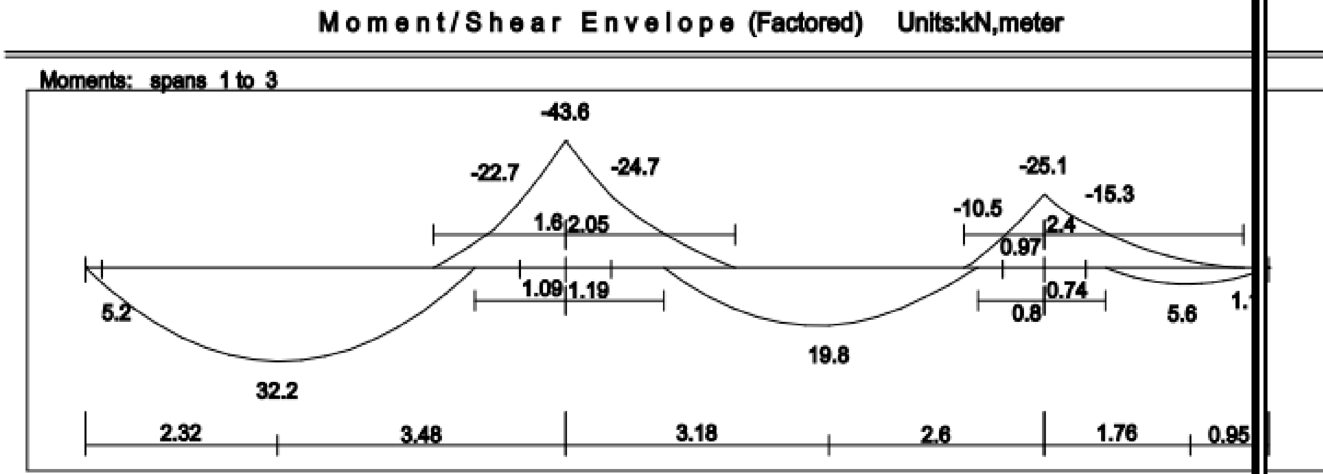


Figure (4-3): Moment Envelop of rib (1)

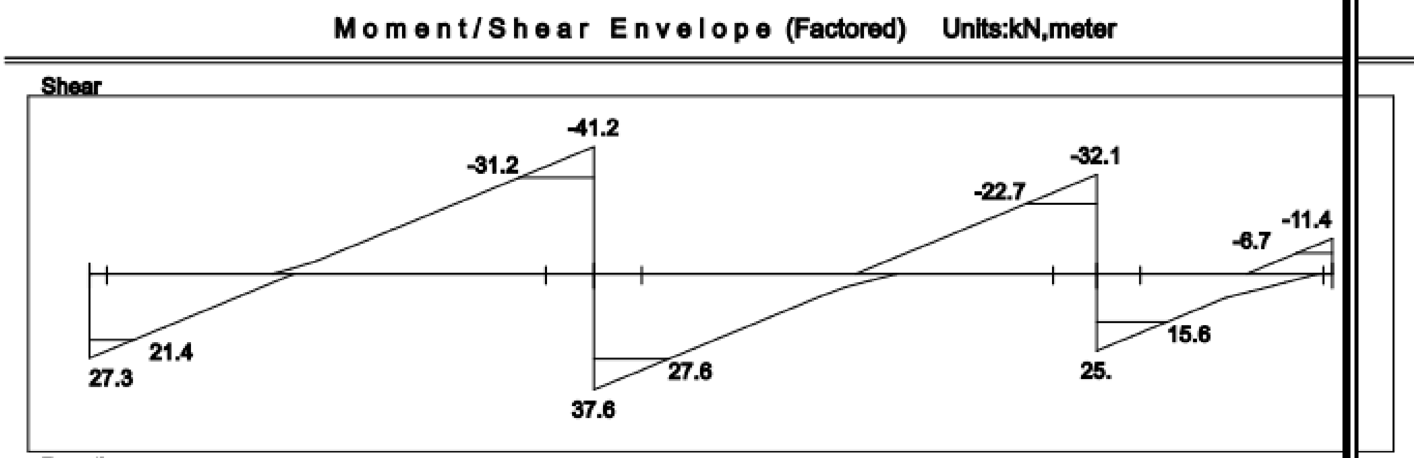


Figure (4-4): Shear Envelop of rib (1)

4.5.1 Design of flexure: -

4.5.1.1 Design of Positive moment of rib (RIB 1):

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

$= 350 - 20 - 10 - \frac{12}{2} = 314$ mm.

→$M_{u\ max}$ = 32.2 KN.m

be ≤ Distance center to center between ribs = 540 mm………… Controlled.

≤ Span/4 = 5800/4 = 1450 mm.

≤ (16* t_f) + b_w =(16* 80) +140 =1420 mm.

→b_e= 540 mm.

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

$$= 0.85 * 24 * 540 * 80 * \left(314 - \frac{80}{2}\right) * 10^{-6} = 241.47\ KN.m$$

ϕM_{nf} = 0.9 * 241.47 = 217.32 KN.m

→ϕM_{nf} =217.32> $M_{u\ max}$= 32.2 KN.m.

∴ the section will be designed as rectangular section with b=be=540mm

1) Maximum positive moment $Mu^{(+)}$ = 32.2 KN.m

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

$$R_n = \frac{M_U}{b\phi * d^2} = \frac{32.2*10^6}{540*0.9*(314)^2} = 0.672\ \text{MPa}$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.671*20.58}{420}}\right) = 0.001624$$

→A_s = ρ * b *d = 0.001624 * 540 * 314= 275.36 mm^2.

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

$$= \frac{\sqrt{24}}{4*420} * 140 * 314 \ \geq \ \frac{1.4}{420} * 140 * 314$$

= 128.2 mm^2<146.53 mm^2 ………… Larger value is control.

→As_{min} = 146.53 mm^2<As_{req} = 275.36 mm^2.

∴ As = 275.36 mm^2.

2 Φ14 =307.88 mm^2>As_{req} = 275.36mm^2 . OK.

∴ Use 2 Φ14

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

Tension = Compression

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

307.86* 420 = 0.85 * 24 * 540 * a

a = 11.7375 mm.

f_c' = 24 MPa< 28 MPa→ β_1 = 0.85

$c = \frac{a}{\beta_1} = \frac{11.7375}{0.85}$ = 13.81 mm.

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

= $\frac{313-13.81}{13.81}$ * 0.003 = 0.06499 > 0.005   ∴ ϕ =0.9 … OK!

4.5.1.2 Maximum negative moment $M_U^{(-)}$ = -24.7 KN.m

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

$R_n = \frac{M_U}{b*\phi*d^2} = \frac{24.7*10^6}{140*0.9*(314)^2}$ =1.988 MPa

$\rho = \frac{1}{m}\left(1 - \sqrt{1-\frac{2*R_n*m}{f_y}}\right) = \frac{1}{20.58}\left(1 - \sqrt{1-\frac{2*1.988*20.58}{420}}\right)$= 0.004989

→A_s = ρ * b *d = 0.004989* 140 * 314= 219.316mm^2.

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

$= \frac{\sqrt{24}}{4*420} * 140 * 314 \;\geq\; \frac{1.4}{420} * 140 * 314$

= 128.2 mm^2<146.53 mm^2 ………… Larger value is control.

→As_{req} =219.316mm^2≥ As_{min}= 146.53 mm^2.

∴ As = 219.316mm^2.

2 Φ14 =307.86 mm^2>As_{req} =219.316mm^2. OK.

∴ Use 2 Φ14

4.5.2Design of shear of rib (RIB 1):

1) Vu =31.2KN.

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

$= 1.1 * \frac{\sqrt{24}}{6} * 140 * 313 * 10^{-3} = 39.36$ KN.

$\phi V_c = 0.75 * 39.36 = 29.52$ KN.

→Check for Cases: -

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

$31.2 \leq \frac{29.52}{2} = 14.76$

∴ Case (1) is NOT satisfied

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

$14.76 \leq 31.2 \leq 29.52$

∴ Case (2) is NOT satisfied → shear reinforcement is required.

Vs = $\frac{V_u}{\phi} - Vc = 2.24$

Vs max = $\frac{2}{3} * \sqrt{f_c'} * d * b_w = \frac{2}{3} * \sqrt{24} * 140 * 313 * 10^{-3} = 143.11$

Vs′ = $\frac{\text{Vs max}}{2} = 71.56$

Vs min=$\frac{1}{16} * \sqrt{f_c'}$ * b_w*** d** =13.42

Vs min=$\frac{1}{3}$* b_w*** d** = 14.61 ....**Control.**

Try 2Φ8: -

$\frac{100.5*420*313}{S}$ = 14.61*10^3 → S = 904.3 mm.

S ≤$\frac{d}{2}$ = $\frac{313}{2}$ = 156.5 mm. … **Control**

≤ 600 mm.

∴ **Use 2Φ8 @ 15 Cm**

DESIGN OF ISOLATED FOOTING (2)

Loads that act on footing F2 are :

- PD =1738.14 kN , PL = 363.387 kN
- Pu = 1.2 * 1738.14 + 1.6*363.387 = 2667.187kN

The following parameters are used in design :

- $\gamma_{concrete}$ = 25 kN/m^3
- γ_{soil} = 18 kN/m^3
- σ_{allow} = 400 kN/m^2
- clear cover = 10cm
- service surcharge =5 kN/m^2

Determination of footing dimension (a)

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

→ Assume h = 60cm

→ $\sigma_{b(allow)net}$ = 400 – 25*0.60– 0.5*18 - 5 = 371 kN/m^2

→ $A = \frac{P_n}{q_{a.net}} = \frac{1738.14+363.387}{371} = 5.66\ m^2$

→ $l = \sqrt{A} = \sqrt{5.66} = 2.379\ m$

→ Select $l = 2.40\ m$

Determination of footing depth (h)

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

→ $q_u = \frac{P_u}{A} = \frac{2667.187}{5.66} = 463.05KN/m^2$

Design of one way shear

$d = h - cover - \emptyset = 600 - 100 - 16 = 484mm$

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

$= 463.05 * 2.40\left(\frac{2.40}{2} - \frac{0.45}{2} - 0.484\right)$

$= 545.658KN$

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

$= 0.75 * \frac{1}{6} * \sqrt{24} * 2400 * 484 = 711.33$ kN >Vu

∴ **h = 60cm is correct** ✓

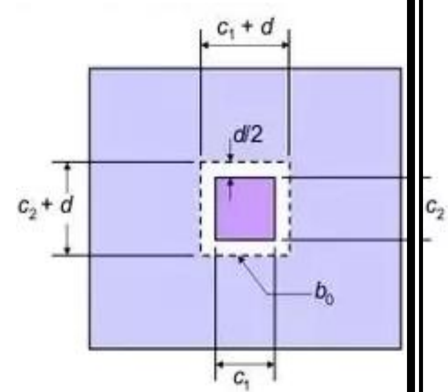


Figure 4- 1 Two way Shear (Punching)

Design of Punching (two way shear)

→ $d = 484\ mm$

→ $b_o = 2(0.70+0.484)+ 2(0.45+0.484) = 4.236$ m

→ $\beta = 1.555$

→ $\alpha s = 40$ (interior column)

Vu = 463.05(2.40*2.40-(0.70+0.484)(0.45+0.684)) = 2155.10kN

ØVc is the smallest of :

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

$= \frac{1}{6}\left(1 + \frac{2}{1.555}\right) \times \sqrt{24} \times 4236 \times 484 \times 10^{-3} = 3826.994KN$

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

$= \frac{1}{12}\left(\frac{40 \times 484}{4236} + 2\right) \times \sqrt{24} \times 4236 \times 484 \times 10^{-3} = 5499.003\ KN$

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

$= \frac{1}{3} \times \sqrt{24} \times 4236 \times 484 \times 10^{-3} = 3344.599\ kN$ ∢ **cont.**

→ ØVc = 0.75 × 3344.599 = 2508.49 kN > Vu = 2155.10 kN

∴ **h = 60 cm is correct ✓**

Design of Reinforcement

Mu = 463.05 *2.40*0.975*(0.975/2) = 528.224 kN.m

→ $m = \frac{Fy}{0.85*Fc'} = \frac{420}{0.85*24} = 20.588$

→ Mn = 528.224/0.9 = 586.9155 kN.m

→ $Rn = \frac{Mn}{b*d^2} = \frac{586.9155*10^6}{2400*484^2}$ = 1.043 MPa

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

$= \frac{1}{20.588} * (1- \sqrt{1 - \frac{2*1.043*20.588}{420}}) = 0.00255028$

→ $Asreq = \rho * b * d = 0.00255028 * 2400 * 484 = 2962.41\ mm^2$

→ As (min) = 0.0018*b*h = 0.0018*2400 * 600 = 2592 mm^2

→ Asreq > As (min)

∴ **Select for both directions: 15Ø16 with As = 3014.4mm^2 > Asreq … (ok)**

Design of Reinforcement

Mu = 463.05 *2.40*0.85*(0.85/2) = 401.464 kN.m

→ m = $\frac{Fy}{0.85*Fc'} = \frac{420}{0.85*24} = 20.588$

→ Mn = $401.464/0.9$ = 446.0711 kN.m

→ Rn = $\frac{\text{Mn}}{\text{b*d}^2} = \frac{446.0711*10^6}{2400*484^2}$ = 0.7934 MPa

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

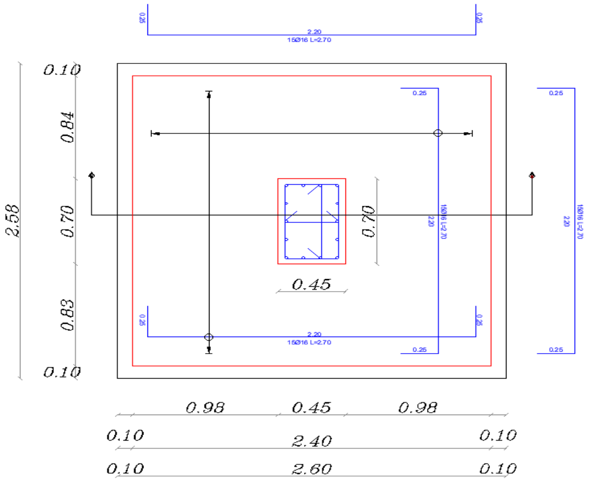
$= \frac{1}{20.588} * (1- \sqrt{1 - \frac{2*0.7934*20.588}{420}}) =$ 0.00192728

→ Asreq = $\rho * b * d = 0.00192728 * 2400 * 484 = 2238.7329$ mm^2

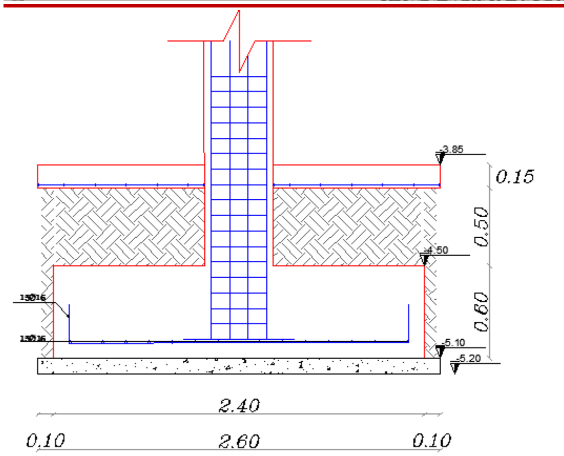
→ As (min) = 0.0018*b*h = 0.0018*2400 * 600 = 2592 mm^2

→ As (min) > Asreq

∴ **Select for both directions: 15Ø16 with As = 3014.4mm^2 > Asmin… (ok)**

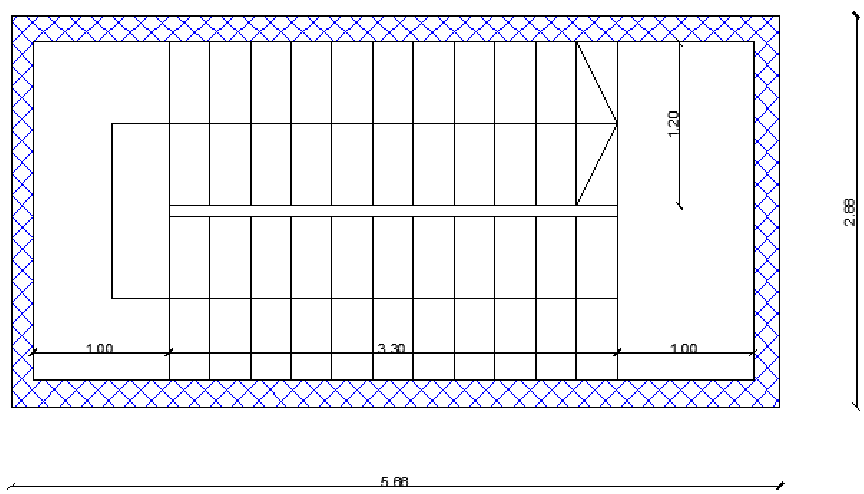


0.10
0.84
0.70
0.83
0.10
2.58
0.70
0.45
0.98
0.45
0.98
0.10
2.40
0.10
0.10
2.60
0.10



0.15
0.50
0.60
2.40
0.10
2.60
0.10

DESIGN OF STAIR



1. **Determination of flight thickness :**

   Limitation of deflection: h ≥ minimum h

   h (min) = L/20 =410/20 = 20.5cm

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

   Angle (α): tan(α) = 17.5/30 → α = 30.26°

2. **Loads calculation :**

Figure (4-23) shows a section in the flight in which the layers carried by the flight appear.

Table(4- 1): Calculation of Dead Loads that act on Flight

Flight Dead Loads
Flight = (0.20 * 25*1)/ cos(30.26) =5.788 kN/m
Plaster = (0.03 * 22*1)/ cos(30.26) =0.76411kN/m
Mortar = 0.03*22*1*($\frac{0.175+0.30}{0.3}$) = 1.045kN/m
Tiles = 0.03*23*1*($\frac{0.175+0.35}{0.3}$) = 1.2075kN/m
Stair step =25/0.3*($\frac{0.175+0.30}{2}$)*1=2.1875 kN/m
Sum=11 kN/m

Take live load=5 kN/m^2

Total factored load

Wu=1.2*11+1.6*5

=21.2 kN/m

4. Design :

Check for shear design :

Assume bar diameter for main reinforcement Ø14

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

vu=41.54-16.412(0.10+0.175)

=37.026 kN

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

$= 0.75 * \frac{1}{6} * \sqrt{24} * 1000*173*10^{-3}$

=105.938 kN

ØVc/2=52.696 kN

ØVc/2=52.696 kN > Vu max = 37.026 kN

∴ the thikness of the flight is adequate enough

- **Design of Bending Moment :**
- Mu=41.54(4.1/2)-(16.412*0.4(0.4+1.65)-21.2*1.65*0.825
- Mu=42.84 kN.m

$\rightarrow$ $m = \frac{Fy}{0.85*Fc'} = \frac{420}{0.85*24} = 20.588$

$\rightarrow$ $Rn = \frac{Mu/Ø}{b*d^2} = \frac{42.84*10^6/0.9}{1000*173^2} = 1.5904MPa$

$\rightarrow \rho = \frac{1}{m} * (1- \sqrt{1 - \frac{2*Rn*m}{Fy}}) = \frac{1}{20.588} * (1- \sqrt{1 - \frac{2*1.5904*20.588}{420}}) = 0.003947$

$\rightarrow$ Asreq $= \rho * b * d = 0.003947 * 1000 * 173 = 682.831$ mm^2

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

∴ Select **Ø14/20 with As = 769.3 mm^2** > As req …. For Main Reinforcement

For secondary Reinforcement select **Ø10 /20 with As=395 mm^2** = As min

→ Check Spacing :
→ S=200mm
→ S is smallest of :
→ 3*h=
3*200=600mm
→ 450mm
→ $380\left(\frac{280}{f_s}\right) - 2.5Cc$
$380\left(\frac{280}{0.667*420}\right) - 2.5*20 = 330mm$
→ $300\left(\frac{280}{0.667*420}\right) = 300mm$ ∢ **cont.**
→ S=200mm<300 OK

Design of Landing

- Determination of Landing thickness :

Limitation of deflection:

h ≥ minimum h

h (min) = L/20 = 270/20 = 13.5 cm

∴ Select h = 15 cm , but shear and deflection must be checked

- Loads calculation :

Table(4- 2):Calculation of Dead Loads that act on Landing

Landing Dead Loads
Tiles = 0.03*23*1=0.69 kN/m
Mortar = 0.03*22*1=0.66 kN/m
Slab = 0.15*25*1=3.75 kN/m

Plaster = 0.03*22*1=0.66 kN/m
Sum = 5.76 kN/m

Factored Loads :

qu = 1.2*5.76+1.6*5 = 14.912 kN/m

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

qu = 14.912 + Support reaction of flight = 14.912 + 15.385 = **30.297 kN/m**

→ **Analysis :**

→ d=150-20-(12/2)

=124mm

Take the maximum shear as the support reaction = 40.90 kN

→ d=124mm & Vu max=40.90 kN

$Ø \times Vc = 0.75 * \frac{1}{6} * \sqrt{24} * 1000 * 124*10^{-3}$=75.9kN > Vu max = 40.90 kN

∴ No Shear Reinforcement is Required #

→ **Bending Moment Design : (Mu max = 27.608kN.m)**

- m = 20.588
- Rn = $\frac{27.608 * 10^6/0.9}{1000*124^2}$ = 1.995MPa
- $\rho = \frac{1}{20.588} * (1- \sqrt{1 - \frac{2*1.995*20.588}{420}}) = 0.005008$
- Asreq = $0.005008 * 1000 * 124 = 621.016$ mm^2
- As min = 0.0018 *1000*150 = 270 mm^2

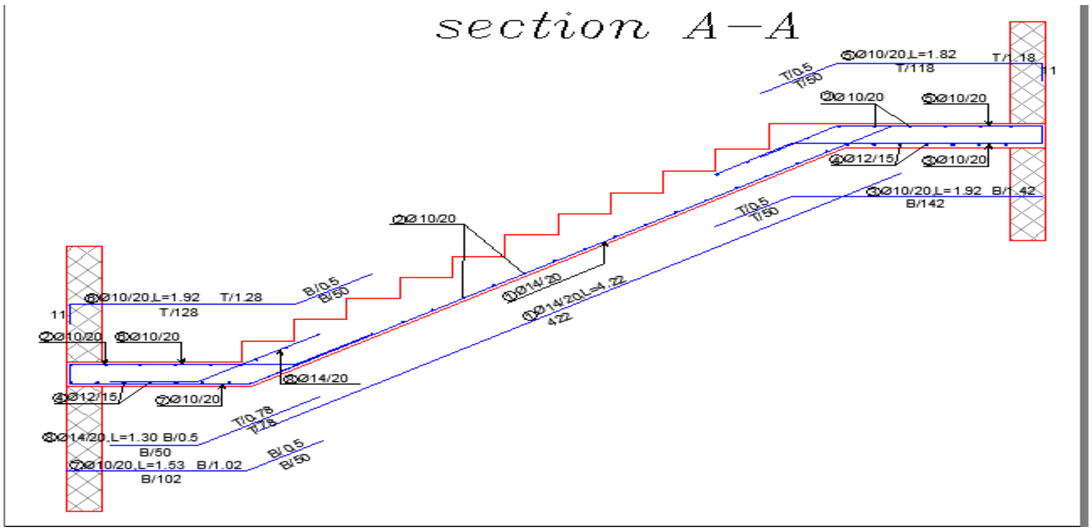
∴ Select **Ø12/15cm with As = 754 mm^2** > As req …. For Main Reinforcement

- Check Spacing :
- Check Spacing :
- S=150mm
- S is smallest of :
- 3*h=
  3*150=450mm
- 450mm

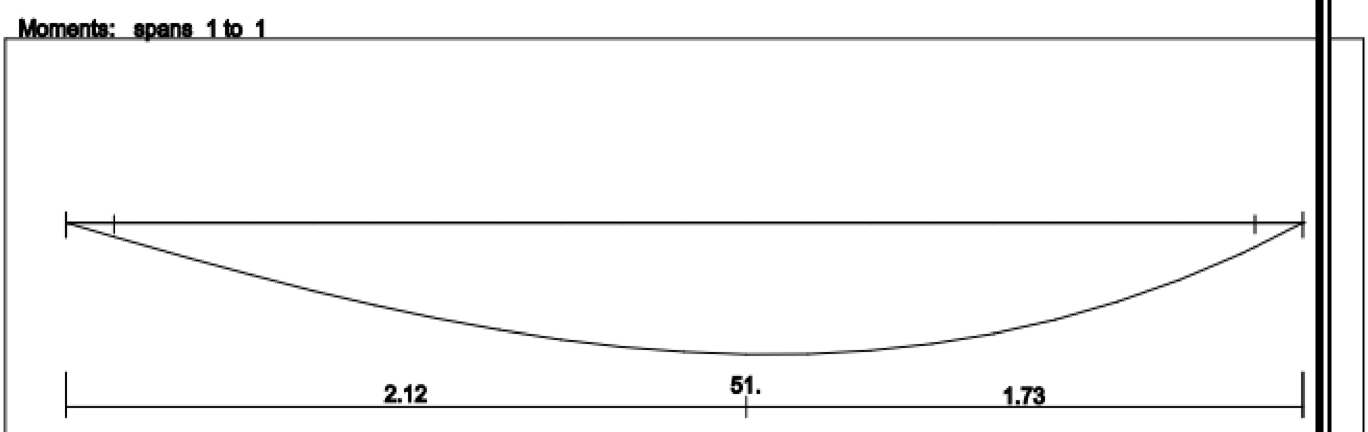
- $380\left(\frac{280}{f_s}\right) - 2.5Cc$

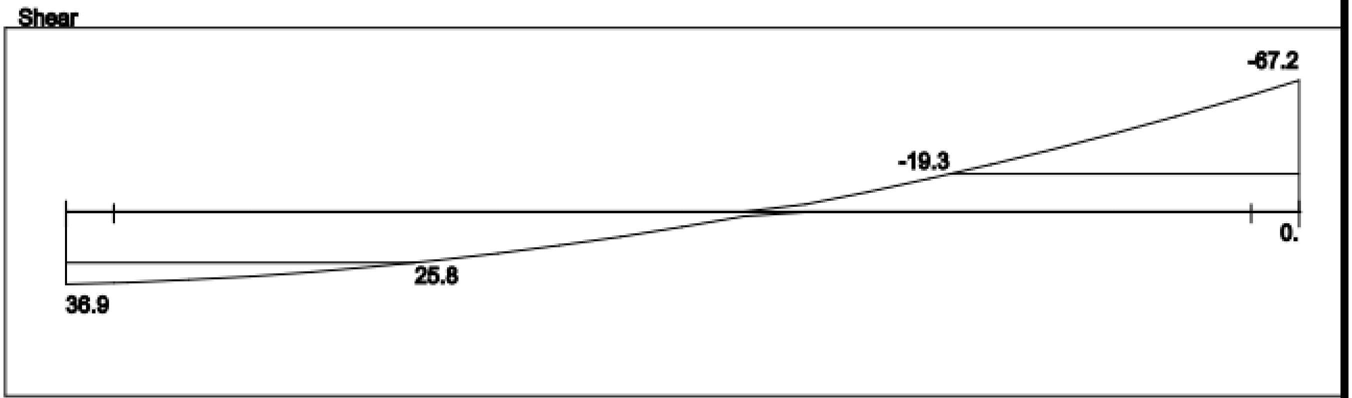
  $380\left(\frac{280}{0.667*420}\right) - 2.5*20 = 330mm$
- $300\left(\frac{280}{0.667*420}\right) = 300mm \prec$ **cont.**
- S=150mm<300 OK

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



Design of basement wall:





Assume wall thikness 200mm

Assume bar diameter Ø16

d=200-75-16/2=117mm

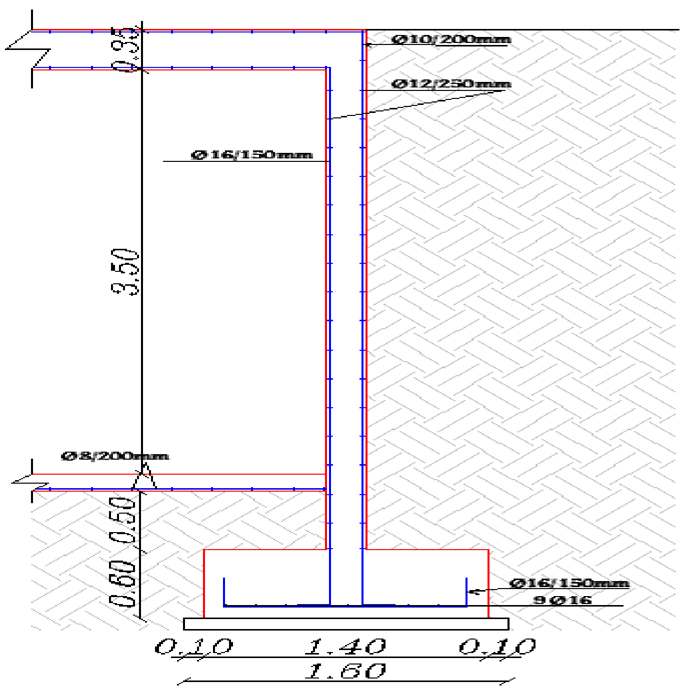
- m $= 20.588$
- Rn = $\frac{51 * 10^6 / 0.9}{1000 * 117^2}$ = 4.1395MPa
- $\rho = \frac{1}{20.588} * (1 - \sqrt{1 - \frac{2 * 4.1395 * 20.588}{420}}) =$ 0.0111314
- Asreq $= 0.0111314 * 1000 * 117 = 1302.383$ mm^2
- Verticle As min = 0.0015 *1000*200 = 300 mm^2 /m
- $\frac{0.25\sqrt{f_c'}}{fy} b_\omega d = \frac{0.25\sqrt{24}}{420} * 1000 * 117$
- =341.173mm^2
- $\frac{1.4}{f_y} b_\omega d = \frac{1.4}{420} * 1000 * 117$
- =390mm^2
- n=1302.383/200.96 =6.48 take 7Ø16/m or Ø16 /150

- for horizontal reinforcement :

- $AS_{horizontal}$=0.002*b*h = 0.002*1000*200

- =400mm^2/m

- Use Ø12/250 on each side of the wall



DESIGN OF SHEAR WALL:

Analysis and design were done using ETABS program in which the seismic loads were taken into account. The following is a sample calculation for one of the walls, S.W12.

The following data that used in design**:**

- Shear Wall thickness = h = 20 cm

- Shear Wall length Lw = 4.88m
- Building height Hw=12.37 m
- Critical section shear :

Lw/2=4.88/2=2.44   ….. control

hw/2=12.37/2=6.185

story height=4.26

→ d =0.8*Lw =0.8*4.88 = 1.952 m

4.11.1 Design of Horizontal Reinforcement

Calculation of Shear Strength Provided by concrete Vc:

- Shear Strength of Concrete is the smallest of :

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

= $\frac{1}{6}\sqrt{24} \times 200 \times 1952 = 318.76\text{kN} \ll \text{Controlled}$

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

= $0.27\sqrt{24} \times 200 \times 1952 + 0 = 516.38\ KN$

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

Where:

- Mu= 692.5 kN.m

- $\frac{Mu}{Vu} - \frac{Lw}{2} = \frac{692.5}{148.327} - \frac{4.88}{2} = 2.239 > 0$ → This equation is applicable.

0.2449

$\therefore Vc = 318.76$ kN $\rightarrow$ $\emptyset Vc = 2390.7 > Vumax^{1} = 148.327$ kN

but $\left(\frac{\text{Avh}}{\text{s}}\right)\text{min} = 0.0025 * \text{h} = 0.0025 * 200 = \mathbf{0.500}$.

$\rightarrow$ Avh : For 2 layers of Horizontal Reinforcement

Select Ø10 :

Avh = 2 *79 = 158 mm^2

$$\frac{Avh}{s} = 0.625 \rightarrow Sreq = \frac{158}{0.500} = 316\ mm$$

Smax= Lw/3 = 4880/3 = 1626.667 mm

= 3h = 3*200 =600mm

$= 450mm \ll$ Controlled.

∴**<u>Select Ø10 @ 250mm at each side.</u>**

4.7.2 Design of Vertical Reinforcement

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

$$\frac{hw}{lw} = \frac{12.37}{4.88} = 2.5348 > 2.50$$

$\rightarrow$ $\frac{Avv}{Sver} = [0.0025 + 0.5\ (2.5 - 2.5348)(0.0025 - 0.0025) = 0.0025$

Smax= Lw/3 = 4880/3 = 1626.667 mm

= 3h = 3*200 =600mm

$= 450mm \ll$ Controlled

Select Ø10

∴**Select Ø10@ 300 mm at each side.**