*Palestine polytechnic university*

*College of engineering & technology*

*Department of civil engineering & architecture*

*Building engineering*

*Graduation Project*

**NAME OF PROJECT**

# Structural designs for School

**TEAM OF WORK**

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**SUPERVISOR**

**DR. Nafith Nasraldean**

**2020-August**

*Palestine polytechnic university*

*College of engineering & technology*

*Department of civil engineering & architecture*

*Building engineering*

*Introduction to Graduation Project*

**NAME OF PROJECT**

**TEAM OF WORK**

**NAME OF PROJECT**

**Structural Designs for Al-Hayat Hospital**

**On the instructions of the professor supervising the project and with the approval of all the members of the examiner, this project is submitted to the Department of Civil engineering and architecture in the Faculty of Engineering to meet the requirements of the Department for bachelor's degree.**

**Project supervisor's signatureSignature of the head of the department**

**DR. NAFETH NASERALDEENDR. Faydi Shabana**

………………………....                                        ………………………...

**2020-August**

# Abstract

The main objective of the project is to make a structural design for all the structural elements that the project contains, from foundations, walls, columns, beams, slabs and many other structural elements in the building.

The project consists of six floors and three floors, car garages and outdoor car parks. The floors have a variety of services with a total area of 22,375 square meters. The design from an architectural point of view is distinguished by that it was done in a modern civilized style based on containing several space blocks distributed in a symmetrically functional and aesthetic manner, as it is In the distribution of space blocks, consideration was given to providing users with convenience, speed and ease of access.

The importance of the project lies in the diversity of the structural elements in the building such as beams, columns, concrete slabs, the multiplicity of blocks and the presence of retreats in the floor space.

It is worth noting that the Jordanian code will be used to determine live loads and to determine earthquake loads. As for structural analysis and section design, the American code(ACI_318_14) will be used, and it must be noted that some computer programs such as: -
AutoCAD (2016), Atir and Microsoft Office The project will include a detailed structural study of identifying and analyzing the structural elements and the various expected loads, then the structural design of the elements and preparing the operational plans based on the prepared design of all the structural elements that make up the structural structures of the building. It is expected after the completion of the project to be able To provide the structural design for all the structural elements, God willing.

## الإهـــــــداء

**إلى الشموع التي** استطاعت قهر الظلام بقوة إرادة نورهما... الذين كلما مر الوقت أكثر

نفهم كم هو صعب أن نحاول سداد ديوننا لهم.... خاصة عندما يكون **"الثبات"**

على ما نؤمن به...هو من بعض غرسهم

أمهاتنا وآبائنا أدام الله نورهم..

إلى العلم، والتربية، **والوقار، والإخلاص، والتواضع**

**أساتذتنا الكرام..**

**إلى دعائم قوتنا وطموحنا.... بلسم علتنا وجروحنا**

**إخواننا وأخواتنا.....**

إلى كل الاوفياء المخلصين الذين جعلوا من الوفاء شمعة تنير دربهم

إلى من يجسدون الوفاء **في أرقى صوره**

اصدقائنا وصديقاتنا رفقاء **الدرب..**

**وإلى كل من** أخذ ويأخذ بأيدينا إلى قمة المجد

نهدي هذا **المشروع**..

# الشـــكـــر والتـــقـــديـــر

ليس هناك شكرا **أعظم من الاعتراف** بالجميل، وليس هناك مشكور أعظم من صاحب

**الفضل الذي**

لا ينقطع فضله ولا تنحصر نعمه. فالحمد لله حمدا لا ينتهي عند حد ولا ينقطع عند أجل.

ووفي هذا المقام لا يسعنا إلا **أن نتقدم** بجزيل شكرنا، وعظيم امتناننا وتقديرنا؛ إلى كل من ساهم في انجاز مشروعنا هذا متحدين معنا كل الصعاب فلهم جميعا الشكر والتقدير كله.

ونخص بشكرنا وتقديرنا أستاذنا الفاضل الدكتور ماهر عمرو المشرف والموجه **والمعلم، الذي** لم يتوان ولم يتأخر عن تقديم ما أتاه الله من علم وحلم لنا.

**ونشكر** طاقم دائرة الهندسة المدنية والمعمارية كل بمكانه الذين كرسوا وقتهم وجهودهم **لمساعدتنا ومساعدة زملائناطوالسنوات الدارسة.**

كما نتقدم بشكرنا إلى زملائنا وزميلاتنا الأعزاء الذين لولا وجودهم لما **أحسسنا بمتعة المشروع،** ولا حلاوة المنافسة الإيجابية.

وختام القول مسك فالشكر كل الشكر الى ابائنا وامهاتنا واخواننا الذين لهم الدور الاكبر في الوصول لما وصلنا اليه ولعلنا نوفيهم حقهم ببلوغنا رضاهم جميعا.

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# List of Abbreviations

- **Ac = area of concrete section resisting shear transfer**
- **As = area of non-pre-stressed tension reinforcement.**
- **$AS`$ = area of non-pre-stressed 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.**
- **Cc = compression resultant of concrete section.**
- **Cs = 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.**
- **$fc`$ = compression strength of concrete.**
- **fy = specified yield strength of non-pre-stressed 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.**

- **$P_u$ = factored axial load**
- **S = Spacing of shear in direction parallel to longitudinal reinforcement.**
- **$V_c$ = nominal shear strength provided by concrete.**
- **$V_n$ = nominal shear stress.**
- **$V_s$ = nominal shear strength provided by shear reinforcement.**
- **$V_u$ = factored shear force at section.**
- **$W_c$ = weight of concrete.**
- **W = width of beam or rib.**
- **$W_u$ = factored load per unit area.**
- **Φ = strength reduction factor.**
- **$\varepsilon_c$ = compression strain of concrete = 0.003.**
- **$\varepsilon_s$ = strain of tension steel.**
- **$\varepsilon'_s$ = strain of compression steel.**
- **ρ = ratio of steel area.**

# Chapter 1
# Introduction of the project

- **1.1 Introduction**

- **1.2 Project overview**

- **1.3 What is the problem that facing this project?**

- **1. 4 why this project was chosen?**
- **1. 5 The purpose of this project**

- **1. 6 The purpose of this project**
- **1. 7 Scope of the project**
- **1. 8 Scope of the project**

## 1.1 Introduction

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 to our health and well-being.

**Civil engineers:**

- Measure and map the earth's surface.
- Design and supervise the construction of bridges, tunnels, large buildings, dams, and coastal structures.

Plan, layout, construct, and maintain railroads, highways, and airports.
Devise systems for the control and efficient flow of traffic.
Plan and build river navigation and flood control projects.
Provide plants and systems for water supply and sewage and refuse disposal.

To build may be a primal urge. Our constructions, while they may be simply for shelter or transportation, often include aesthetic touches that are there to make us feel good about what we have built. Thus, bridges have geometrical designs intended to support weight, but they also have an artistic detailing and a "look" that defines the era in which they were built. In constructing buildings, highways, and bridges, civil engineers work with architects to develop the appearance of the structure. Ugly buildings represent a failed communication between the two professionals; a building that falls down, or cannot be maintained, also represents a failure, but one that the civil engineer could possibly have prevented. Civil engineering is much more than erecting skyscrapers or bridges.

Civil engineers are trained in the interactions among structures, the earth, and water, with applications ranging from highways to dams and water reservoirs. Deeply involved with specifying appropriate construction materials, many civil engineers and others are also employed by the manufacturers of those materials. Since constructing a large building or public-works project can involve elaborate planning, civil engineers can be outstanding project managers. They sometimes oversee thousands of workers and develop advanced computerization and planning policies. Most significantly, many civil engineers are involved with preserving, protecting, or restoring the environment.

## 1.2 Project overview

We chose one of the hospitals in Yatta, a hospital that specializes in treating cancerous tumors, to provide an introduction to the graduation project and to conduct an integrated structural study that includes structural analysis and design of building elements so that they can withstand loads that affect the building. The project consists of five floors after the ground floor and three floors for car parks with a total area (22375 m 2).

One of the important things a person always searches for is the appropriate design that provides comfort in use, so choose the right place to build the building and search for engineers with the skills and experience to design and implement the building in terms of "electrical and mechanical engineering and construction" so that users find the feeling of being comfortable in the place.

## 1.3 What is the problem that facing this project?

The problem of this project in the work of the structural design of the building that was chosen to be the field of this research, where the study was done in the work of a study of the work of equilibrium of the entire building on implementation to avoid any risk to users of this building, and in this project will be analyzed each of the elements of construction such as : beams, columns, foundations, and other structural elements, and determine the loads located on the structural elements of the loads of live or dead loads resulting from the node and the entire elements built in the structure.

As well as taking into account the safety factor of the building and that the economic aspect and enable the achievement of the highest resistance to safety, and then the work plans of the structural elements that have been designed, to move this project from the proposal to the implementation.

## 1. 4 why this project was chosen?

There are many reasons that led to the selection of this project, including the reasons for being a specialty school, and other reasons can be summarized as follows:

1 - The project is a specialized school that enables us to study and analyze the structural elements in line with the scientific qualifications and skills that we gained through studying in the field of engineering professions.

2- Because this project is widely implemented in our society and the need to implement buildings in an engineering manner.

3- The need to increase the experience and skill of structural design, which we studied and applied in practice by linking the relationship between the theoretical aspects that have been gained from the courses studied in this specialization, and the application of this in this project and its structural elements, and design of structural elements to suit the loads On the structural elements, taking into account the provision of durability, strength, durability and economy.

4- The group that worked on the project needs to be constructive, so that it is similar to the projects carried out at work outside the university

## 1. 5 The purpose of this project

1- Making structural designs for the various structural elements in the project.

2- Training on how to apply between the construction and architectural functions of the building.

3- Linking the relationship between the theoretical aspects that we have gained at the university practical aspects that we have learned in the labor market through courses in the field training.

4- the skills of using the computer in the process of structural design to raise the efficiency and qualifications of the civil engineer before moving to work.

5- Linking information and applying the equations that have been studied in different courses.

6- Know and use the appropriate code.

7- Know the loads to which the building and the effect of loads on it.

8- Preparation of complete structural plans detailed so that any structural engineer can understand these plans.

## 1. 6 The purpose of this project

1- Work of full and detailed study of all architectural plans "general site, plans, elevations, sections".

2- Study of the distribution of structural elements in the building.

3 - Structural study of the building that determined.

4- Structural analysis of some structural elements.

5- Structural design of the selected structural elements.

6- Prepare and draw the structural plans for the design elements.

7 - Writing and finalizing the project.

## 1. 7 Scope of the project

Our study in this project is limited to studies and analysis and designs of structure, where we must do designs for selected and specific elements, such as: ribs and concrete slabs, beams, columns, foundations, and the design of stairs “ flight and landing “ , as well as the work of integrated structural plans in all its details for those

elements, especially studies Constructive, as well as make the necessary architectural modifications, if any, on the architectural design in the event of the possible structural solutions to ensure an integrated project of both architectural and structural aspects.

## 1. 8 Scope of the project

It is summarized in five chapters as follows:

- Chapter One:

Includes an introduction to the project containing the problem of the project, the reasons for the selection of the project, its objectives, and the steps followed for the work of the project.

- Chapter Two:

It includes the architectural description of this project; in terms of the general location, the area plan, the description of the facades and sectors from the architectural point of view and the description of the movement inside the building.

3 - Chapter Three:

This chapter describes the structural description of the project elements.

- Chapter Four:

Contains analysis and design processes for the various structural elements of the project.

- Chapter Five:

This chapter represents the end point with its results and recommendations, which are the product of the work that has been done.

# Chapter 2
# Architectural description

- **2.1 Introduction of architecture description for the project**
- **2.2 About this project**
- **2.3 Location of the Project**
- **2.4 The purpose of choose the location of project**
- **2.5 Floors Description**
- **2.6 Movement Description**
- **2.7 Elevations Description**
- **2.8 Sections Description**

## 2.1 Introduction of architecture description for the project

Architecture is the mother of engineering science, and it is not the birth of this time, but issince the creation of the human who unleashed his talents and thoughts, so move these talents from the life of the caves to the best form of luxury.

The shape of the buildings differs at all times from different eras and there are several forms of this building that distinguish it from the rest of the patterns.

The design process for any structure or building is carried out through several stages until it is fully completed.

First, the architectural design phase will be determined. In this stage, the shape of the structure will be determined and the various functions and requirements for which the building will be constructed are taken; Lighting, ventilation, movement, mobility and other functional requirements.

After completing the architectural design process, the structural design process begins, which aims to choose the structural system that is appropriate to the building’s function and is consistent with its architectural design, and as this process aims to define the dimensions of the structural elements and arm them, in order to resist the various loads that are exposed to these elements that in turn By transferring loads to the foundations that completely transfer the loads to the soil.

## 2.2 About this project

The idea of the project is based on the structural design of a school, taking into account all model architectural standards, through the use The modern architectural character, which includes the different building elements, and takes into consideration all the good and psychological comfort in terms of space, ease of movement, public safety requirements and other things, in addition to taking into account the possibility of construction in the future.

## 2.3 Location of the Project

The design process of any project depends mainly on the study of the site on which the building will be constructed very carefully whether it relates to the geographical location or the expected climatic impacts in the region, so give a general idea of the elements of the site, from clarifying the land on which the building will be built and the relationship of the site to the streets and services Surrounding, the height of the surrounding buildings and the direction of the prevailing wind and the path of the sun.

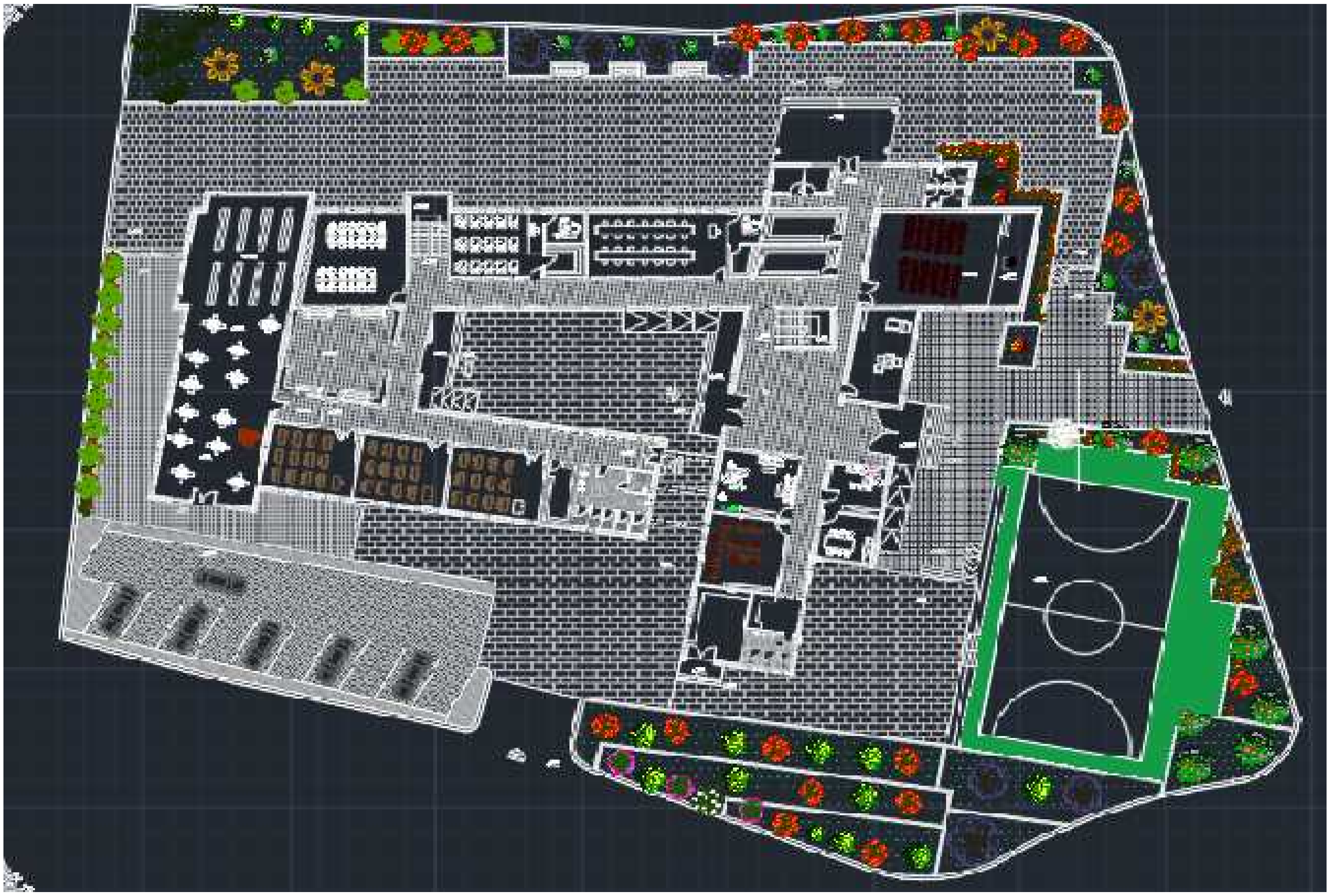
## 2.4 The purpose of choose the location of project

The purpose of choosing this site for the project depends on satisfactory reasons, including the city's need to build this school on this site.

The size of the land is compatible to accommodate this project, and this land site reaches most of the various services of the water and sewage network and that land is located on the main street.

## 2.5 Floors Description

### A. Site Plane:



**Picture 1: site plane**

## B. (Ground Floor G.F)

it consists of three sections for services and bathroomsand its area is 1773$m^2$.

- The first floor contains a library for study and reading with an area of 273.5. It also contains 3 laboratories, 3 teaching rooms, a teacher's room, a room for the director and a secretary, a multi-purpose hall, stores and a meeting room.
- 

**Picture5: Ground Floor G.F**

## C. (first Floor)

it consists of three sections in addition to service rooms and bathroomsand its area is $979m^2$.

The first floor contains 9 classrooms, an auditorium, and bathrooms .

**Picture6: First Floor**

### D. (Second Floor )

it consists of four sections in addition to service rooms and bathroomsand its area is $979m^2$.

- The second floor contains 8 classrooms, a computer lab and bathrooms.

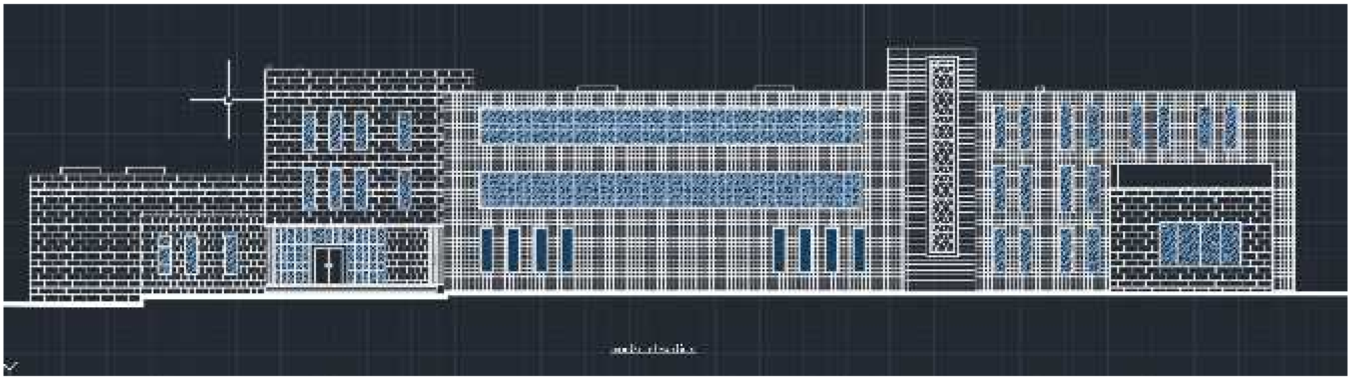
**Picture7: second Floor**

## 2.6 Movement Description

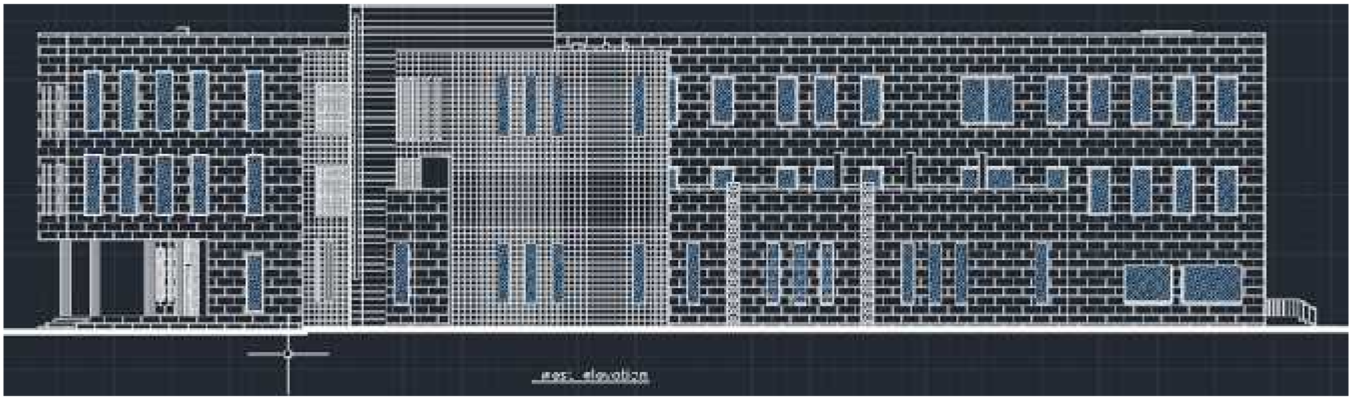
Movement and the process of movement between parts of the building is clear and easy, and is intended to move between rooms and other facilities easily and from within the building to the outside as well, which in turn allows freedom of entry and exit from the building where the movement within the building is divided into two types: horizontal movement within the building and vertical movement Between the floors of the building, which are by stairs, escalators and elevators.

## 2.7 Elevations Description

The four facades of the building are not adjacent to any adjacent buildings, which helped in providing natural lighting and optimal ventilation of the building and the consist of windows in the Elevations of the building that get better in lighting and ventilation of the building, in addition to taking into account the presence of On the ventilation element of the building such as plaque and highlight the architectural beauty element.

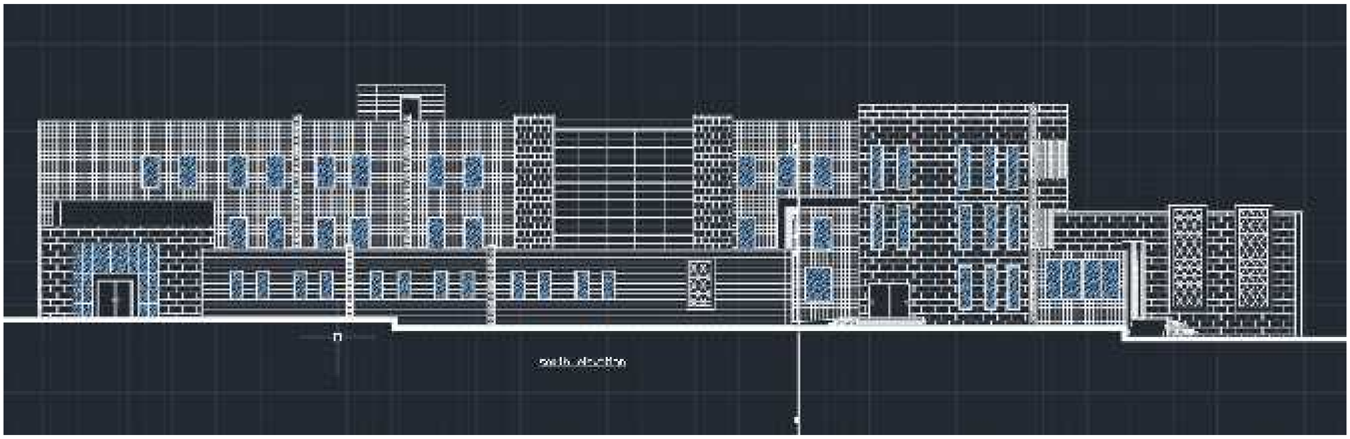


**Picture10: North Elevation**



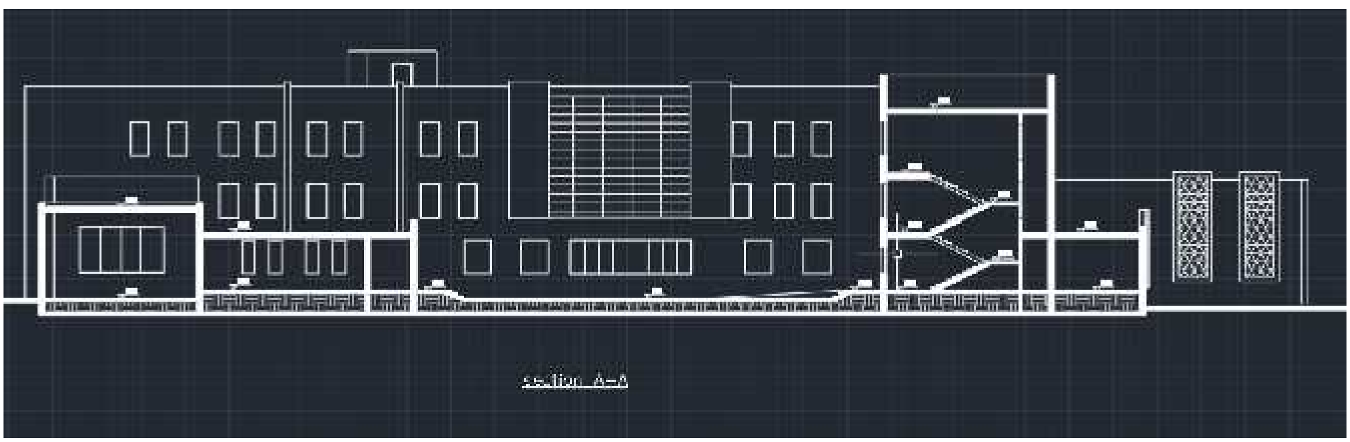

**Picture11: West Elevation**


**Picture12: East Elevation**



**Picture13: South Elevation**

## 2.8 Sections Description




**Picture14: section (A-A)**

# Chapter 3
# Structural descriion

- **3.1 Introduction of Structural description for the project**
- **3.2 Purpose of Structural Design**
- **3.3 The Loads**
- **3.4 Description of Structural Elements**
- **3.5 Expansion joints**

## 3.1 Introduction of Structural description for the project

After the completion of the architectural description in the second chapter is not to move to one of the most important stages that pass during the implementation of any of the construction projects, namely the stage of structural design.

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

## 3.2 Purpose of Structural Design

Structural design work aims to choose a safe construction system that keeps the building as long as possible while remaining fit for the purpose for which it was found, and able to withstand the forces located on it, so that the structure meets the requirements and desires of users, and thus the construction elements are determined based on the following:

- Factor of safety: We can do it through choose a section of structural elements able to withstand the forces and stresses resulting.

- Economic cost (Economy): is achieved by selecting the appropriate building materials and by choosing the ideal low-cost section.

## 3.3 The Loads

Types of loads acting on a structure are:

1 - Dead loads

2 - Live loads

3 - Wind loads

4 - Snow loads

5 - Earthquake loads

### 3 – 3 – 1 Dead Loads

The first vertical load that is considered is dead load. Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self-weight of structural members, permanent partition walls, fixed permanentequipment’sand weight of different materials. It majorly consists of the weight of roofs, beams, walls and column etc. which are otherwise the permanent parts of the building.

The calculation of dead loads of each structure are calculated by the volume of each section and multiplied with the unit weight. Unit weights of some of the common materials are presented in tablebelow.

| No. | Material | Density (KN / m3) |
|---|---|---|
| 1 | Mortar | 22 |
| 2 | Tiles | 23 |
| 3 | R. Concrete | 25 |
| 4 | Hollow Block | 11 |
| 5 | Plaster | 22 |
| 6 | Sand | 17 |

**Table1: Density of material**

## 3 – 3 – 2 Live Loads

The second vertical load that is considered in design of a structure is live loads.

Live loads are either movable or moving loads without any acceleration or impact. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc.

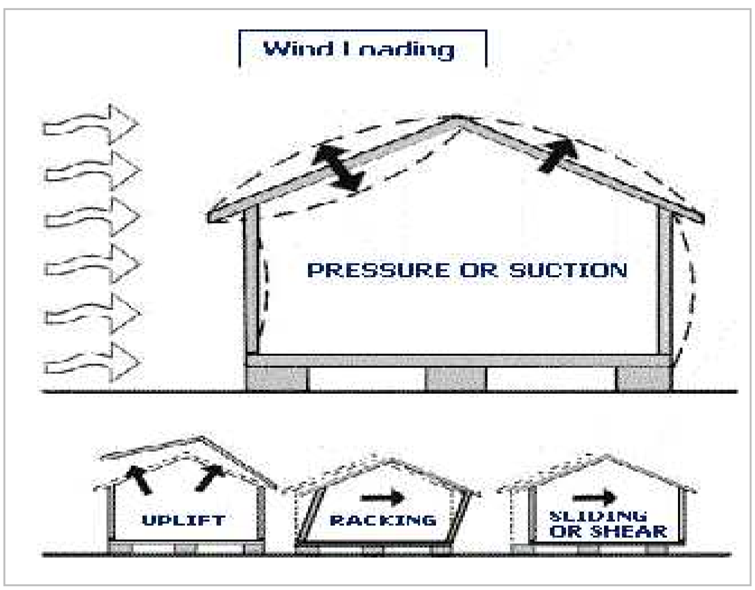
| No. | Using for | Live load ($KN/m^2$) |
|---|---|---|
| 1 | Operations rooms | 3 |
| 2 | The Wings | 2 |
| 3 | Private rooms | 2 |

**Table2: Live load of Jordanian code**

## 3 – 3 – 3 WindLoads

Wind load is primarily horizontal load caused by the movement of air relative to earth. Wind load is required to be considered in structural design especially when the heath of the building exceeds two times the dimensions transverse to the exposed windsurface.

For low rise building say up to four to five stories, the wind load is not critical because the moment of resistance provided by the continuity of floor system to column connection and walls provided between columns are sufficient to accommodate the effect of these forces. Further in limit state method the factor for design load is reduced to 1.2 (DL+LL+WL) when wind is considered as against the factor of 1.5(DL+LL) when wind is not considered.




**Picture16: Wind load**

## 3 – 3 – 4 S n o w Loads

Snowloadsconstitutetheverticalloadsinthebuilding.Butthesetypesofloadsareconsidered only in snowfall places.

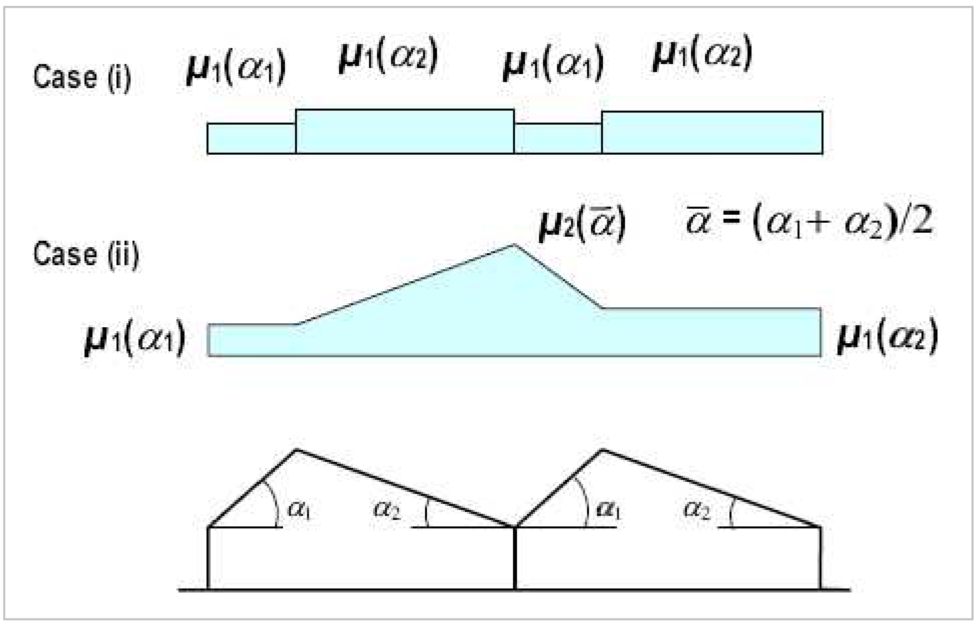
The minimum snow load on a roof area or any other area above ground which is subjected to snow accumulation is obtained by the expression:

$$S = \mu a_0$$

**W** **S = Design snow load on plan area of the**

**μ = Shape coefficient= Shape**

**$\alpha_0$ = Ground snow**




**Picture17: Snow load**

## 3– 3 – 5 EarthquakesLoads

Earthquake forces constitute both vertical and horizontal forces on the building. The total vibration caused by an earthquake may be resolved into three mutually perpendicular directions, usually taken as vertical and two horizontaldirections.

The movement in the vertical direction does not cause forces in the superstructure to any significant extent. But the horizontal movement of the building at the time of earthquake is to be considered while designing.

The response of the structure to the ground vibration is a function of the nature of foundation soil, size and mode of construction and the duration and intensity of ground motion.

The seismic accelerations for the design may be arrived at from the seismic coefficient, which is defined as the ratio of acceleration due to earthquake and acceleration due to gravity. For monolithic reinforced concrete structures located in the seismic zone 2, and 3 without more than 5 stories high and importance factor ‘’ R ‘’ less than 1, the seismic forces are notcritical

## 3.4 Description of Structural Elements

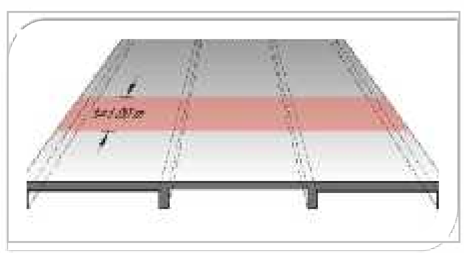
### 3– 4 – 1:Slabs

Slabs are constructed to provide flat surfaces, usually horizontal in building floors, roofs, bridges, and other types of structures. The slab may be supported by walls or by reinforced concrete beams usually cast monolithically with the slab or by structural steel beams or by columns, or by the ground. Slabs are classified into more than 16 types; we will show the top 6 that using in ourcountry.

**Types of slabs that were used in the project**

**1 – One-way SolidSlabs**

One-way slab is a slab which is supported by beams on the two opposite sides to carry the load along one direction.



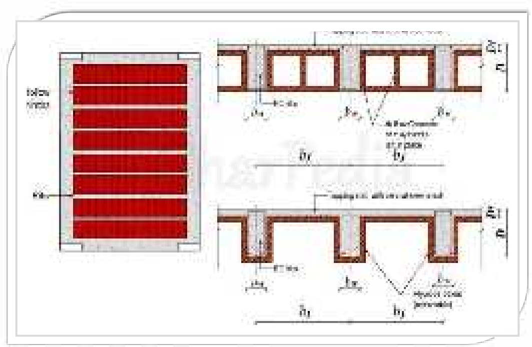
**Picture18: section to One-way Solid Slabs**

The ratio of longer span (l) to shorter span (b) is equal or greater than 2, considered as one-way slab because this slab will bend in one direction i.e., in the direction along its shorter span.

$$2 \le \frac{long\ Span}{Short\ Span}$$

## 2 – One-way RibbedSlabs

A one-way ribbed slab consists of a series of small, reinforced concrete T beams that are connected with girders that in turn carried by the building column. T beams are known as joists which are formed by setting steel pan at a constant spacing.



**Picture 20: section to one-way ribbed Slabs**

- Concrete is cast between those spacingto make those ribs and, in this way, the slab also cast and the slab becomes the flange of T beam.

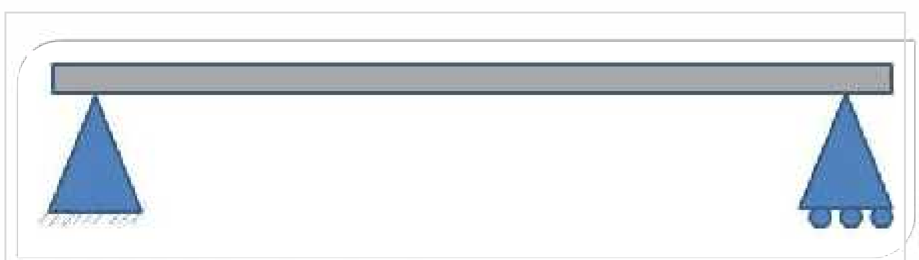
## 3 – 4 – 2:Beams

Different types of beams are used in construction of building and structures. These are a horizontal structural element that withstands vertical loads, shear forces and bending moments. Beams transfer loads imposed along their length to their endpoints to walls, columns, foundations, etc.

### Types of beams:

#### 1 - Simply SupportedBeam

It is one of the simplest structural elements that both ends rest on supports but is free to rotate. It contains pinned support at one end and a roller support at the other end. On the basis of assign load, it sustains shearing and bending.

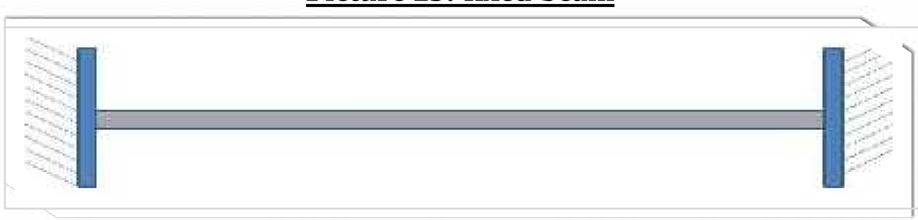


**Picture 24: simply supported beam**

#### 2- FixedBeam

It is supported at both ends and fixed to resist rotation. It is also called a built-in beam. The fixed ends produce fixing moments other than the reactions.

**Picture 25: fixed beam**



## 3- CantileverBeam

If a beam is fixed at one end and set to be free in the end, it is termed as a cantilever beam. The beam distributes the load back to the support where it is forced against a moment and shear stress. Cantilever beams allow the creation of a bay window, balconies, and some bridges.

**Picture 26: cantilever beam**


## 4- ContinuousBeam

A continuous beam has more than two supports distributed along its entire length.

**Picture 27: continuous beam**

## 5- Reinforced ConcreteBeam

It is constructed from concrete and reinforcement as shown

**Picture 28: Reinforced concrete beam**

## 3 – 4 – 3:Columns

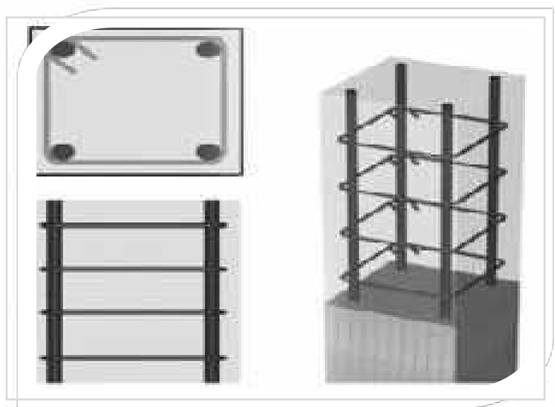
The column is a vertical structural member that carries loads mainly in compression. It might transfer loads from a ceiling, floor slab, roof slab, or from a beam, to a floor or foundations.

## Types ofColumns

### 1- TiedColumn

This type of column is commonly construction from reinforced concrete. Longitudinal reinforcement is confined within closely spaced tie reinforcement.

It is estimated that 95% of all columns in buildings are tied.



**Picture 30: tied column**

# Chapter 4
# Structural design

- **4.1 Introduction of Structural Design**
- **4.2 Design Method and Requirements**
- **4.3 Materials that used**
- **4.4 Design of rib R10as a reinforced concrete (T-Section)**
- **4.5 Design of Beam B1**

## 4.1 Introduction of Structural Design

Structural design is the methodical investigation of the stability, strength, and rigidity of structures. The basic objective in structural analysis and design is to produce a structure capable of resisting all applied loads without failure duringits intendedlife.

The Romans are the first users of the Plain Concrete in the history of about two thousand years and have been used in most of their buildings for ease of formation and the possibility of carrying out them with trained workers with simple training.

Concrete is a mixture of raw materials consisting of sand, grit (or a tooth or broken stone) and cement, with the addition of water to them. And when mixed well, a coherence process between them is called the time of doubt. And concrete has many characteristics that are distinguished from other materials; it takes a solid and solid form with time gradually, begins with primary suspicion and ends with final suspicion. It is also very resistant to Compression, but at the same time, it is very weak in its resistance to tensile. Therefore, Plain concrete is never used in places where tensile stresses occur.

To solve this problem, Steel is placed and it is excellent resistance to tensile forces and pressure forces. While long steel can resist all tensile forces, concrete does not withstand all pressure forces if its sections are thin and occur as a result of this denting of concrete.

Therefore, we find that a mixture of concrete and steel gives an ideal material to resist the various stresses that affect it. This compound is what is known as reinforced concrete

## 4.2 Design Method and Requirements

The design strength provided by a member is calculated in accordance with the requirements and assumptions of ‘’ACI 318-14 ‘’ & Jordan code.

- ✓ Strength design method: -

In ultimate strength design method, the service loads are increased by factors to obtain the load at which failure is considered to be occurring

.

This load called factored load or factored service load. The structure or structural element is then proportioned such that the strength is reached when factored load is acting. 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.**

Factored loads: -

The factored loads for members in our project are determined by:-

**$W_u = 1.2\ D_L + 1.6 L_L$ " ACI 318-14"**

## 4.3 Materials that used

**Concrete: - " B300 "**

$f\acute{c} = 30MPa$ for circular section

But, for rectangular section ($f\acute{c} = 30 \quad 0.8 = 24MPa$ ).

**Reinforcement steel: -**

The specified yield strength of the reinforcement ($Fy = 420MPa$).

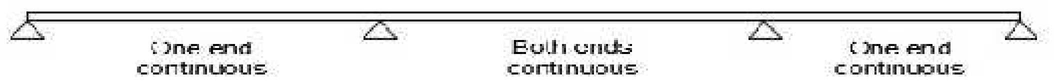
# TOP View

## ➢ Check the minimum thickness of slab

| Minimum thickness | | | | |
|---|---|---|---|---|
| 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 slabs | L/16 | L/18.5 | L/21 | L/8 |

**Table3: Check of Minimum Thickness of Slabs.**

Here, the next system that we will design it:




**Picture 46: system that we will design**

h min (one end conte) = L/18.5 = 600/18.5 = 32.5cm

h min (both end conte) = L/21 = 700 /21 = 33.33cm

We select from one-way ribbed slab, The Thickness of Ribbed slab= 35 cm

**Select 27 cm Block + 8 cm Topping.**

## 4.4Design of Topping

The loads that act on the topping strip:

**Dead Loads**

| NO | Parts of topping | 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 | Interior partitions | 1.5 * 1 = 1.5 KN/m |

**Sum=6.04KN/m**

**Table4: Dead load of topping**

**Live Load: -**

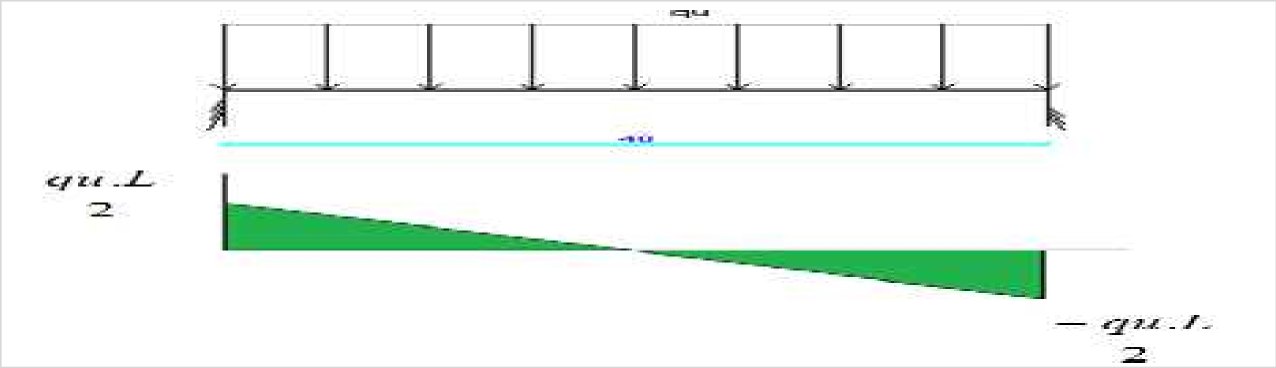
**LL = 5 KN/m2 (by Jordan code for shop rooms).**

**LL=5KN/m2×1m=5KN/m**

**Factored Load: -**

$$q_U = 1.2 \times 6.04 + 1.6 \times 5 = 15.61 KN/m$$

➢ **Design of topping as a plain concrete section:**




**System & Analysis:**

**Vu=** $\frac{qu*l}{2} = \frac{15.61*0.4}{2} =$ 3.122 KN

**Mu=** $\frac{ql^2}{12} = \frac{15.61*0.4^2}{12} =$0.209 KN.m

❖ **Design of Shear Force**

Plain concrete section, one-way shear:

**Ø * Vc = Ø * 0.11 * λ * $\sqrt{f\acute{c}}$ * bw * h**

= Ø * 0.11 * λ * $\sqrt{24}$ *1000* 80=25.87 kN> Vu → **SAFE**

❖ **<u>Design of Bending Moment:</u>**

"b = 1 m & h = 8 cm" Plain concrete section:

**Ø * Mn =** $0.6 * 0.42 * \sqrt{f\acute{c}} * \frac{b*h^2}{6}$

$= 0.6 * 0.42 * \sqrt{24} * \frac{1000*80^2}{6}$ = 1.32 kN.mv > Mu → **SAFE**

"The magnitude of (λ) is 1.0 for normal weight concrete"

So, Plain Concrete Section is SAFE #

**Minimum (As) = 0.0018 * Ag**

**= 0.0018 * b * h**

= 0.0018 * 100 * 8

= 1.44 $cm^2/m$

**→ Select Mesh Ø8/20cm in both directions #**

**As = $(\pi*8^2/4)*(100/20)$ = 2.5 $cm^2/m$ > min As = 1.44 $cm^2/m$**

## 4.5 <u>Design Solid Slab (1) Of The Stair (1)</u>


**Figure (   ) : Solid Slab1 Plane**

❖ **Material :-**

⇒ concrete B300 Fc' = 2٤ N/mm$^2$

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

✓ **<u>Determination of Thickness</u>:-**

$h_{min}$ = L/20 =3400/20 = 17 cm.

Take h = 20 cm

Assume Bar diameter Φ 12 for main reinforcement.
D= h – 20-db/2= 200-20-12/2= 174 mm.

**Table: Calculation of total dead load for solid slab stirs (1).**

| **No.** | **Material** | **Calculation (quality density )** |
|---|---|---|
| **1** | **Tiles** | **23*0.03 = 0.69 Kn/$m^2$** |
| **2** | **Mortar** | **22*0.02 = 0.44 Kn/ m^2** |

| | | | |
|---|---|---|---|
| **3** | **Sand** | **17 *0.07 = 1.19Kn/ m^2** | |
| **4** | **R.C** | **25*0.20 = 5  Kn/ m^2** | |
| **5** | **Plaster** | **22*0.03 = 0.66 Kn/ m^2** | |
| | | **Sum** | **7.98 Kn/$m^2$** |

Live load = 5 KN/$m^2$

Dead load = 7.98 KN / $m^2$

Dead load for 1 m strip of slab D.L = 7.98 * 1 = 7.98 KN/$m^2$

Live load for 1 m strip of slab L.L = 5*1 = 5 KN/$m^2$

**Design Reinforcement  of solid slab stair (1) :**

Wu= (1.2*7.98)+(1.6*5) = 17.57 KN/M.

Mu= (qu*$L^2$ )/8.

Mu= (17.57*($3.4^2$))/8  = 25.38

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{25.38\times10^6}{0.9\times1000\times174^2} = 0.93\ MPa$$

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

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times0.93}{420}}\right) = 0.00226$$

$A_{s,req}$ = ρ.b.d = 0.00226×1000×174 = 393.24 $mm^2$

$A_{s,min}$ = 0.0018*1000*200 = 360 $mm^2$

$A_{s,req}$  = 393.24  mm > $A_{s,min}$ = 360 $mm^2$

$A_{s\ req}$   is control .

Use  **ø12**

**n=AS/ ø12**

**n= 393.24/113 = 3.48  ….. take n= 4 .**

S=1/n = 1 / 3.48 = 0.28

Select  **4 ø12/200 mm**  with As provide = 452m$m^2$> As req = 393.24 m$m^2$

**Check for Spacing:**

S = 3h = 3*200 = 600mm

S = 300*($\frac{280}{\frac{2}{3}*420}$) = 300 mm … control.

S = 450 mm.

**Check for Strain ( Tension Controlled Section ).**

$$a = \frac{A_s.f_y}{0.85 b\, f_c'} = \frac{452\times420}{0.85\times1000\times24} = 9.30\ mm$$

$$c = \frac{a}{B_1} = \frac{9.30}{0.85} = 10.94\ mm$$

d = 200– 20 –12/2 = 174 mm.

$\varepsilon_s$ =

**Shrinkage & temperature reinforcement for one meter strip:**

$A_{s,min}$ = 0.0018*1000*200 = 360 $mm^2$.

Use **ø12**

n=AS/ ø12

n= 360/113 = 3.18 ….. take n= 4.

S=1/n = 1 / 3.18 = 0.314

Select 4 ø12/300 mm with As provide = 452$mm^2$> As req = 360 $mm^2$

Take 4 ø12 /300 both direction .

## ٤-٩-٢Design For Shear .

Vu max = (qu*L)/2 = (17.57*3.4) /2 = 29.86 KN.

ø $V_c$ = $\frac{0.75*1}{6}\sqrt{fc'}b_w\,d = 0.75*0.16*\sqrt{24}*1000*174 = 106.6$ Kn

**Vu max = 29.86 < 0.5 * øVc = 53.3 ….ok**

**No shear reinforcement is Required (Thickness of slab is adequate enough ).**

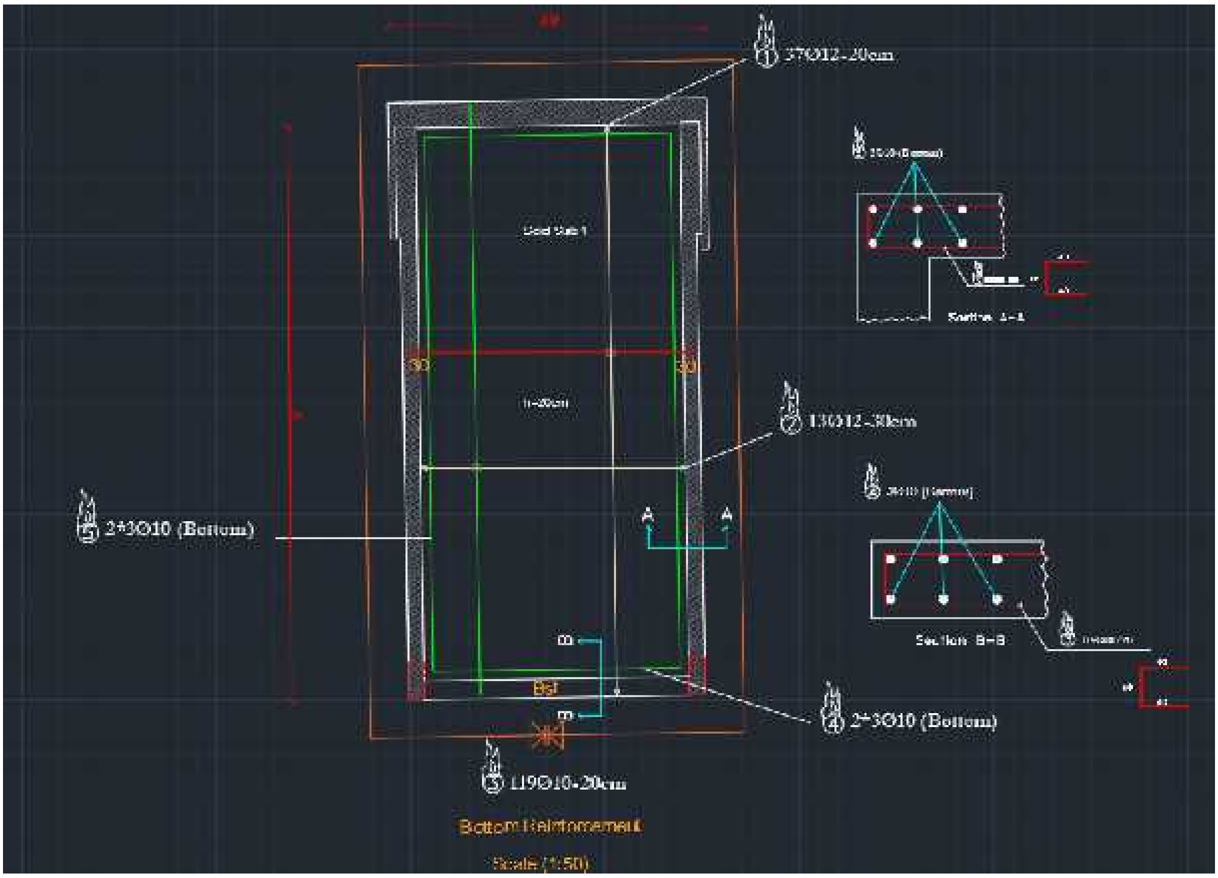



Figure ( ) stair slab(1) reinforcement

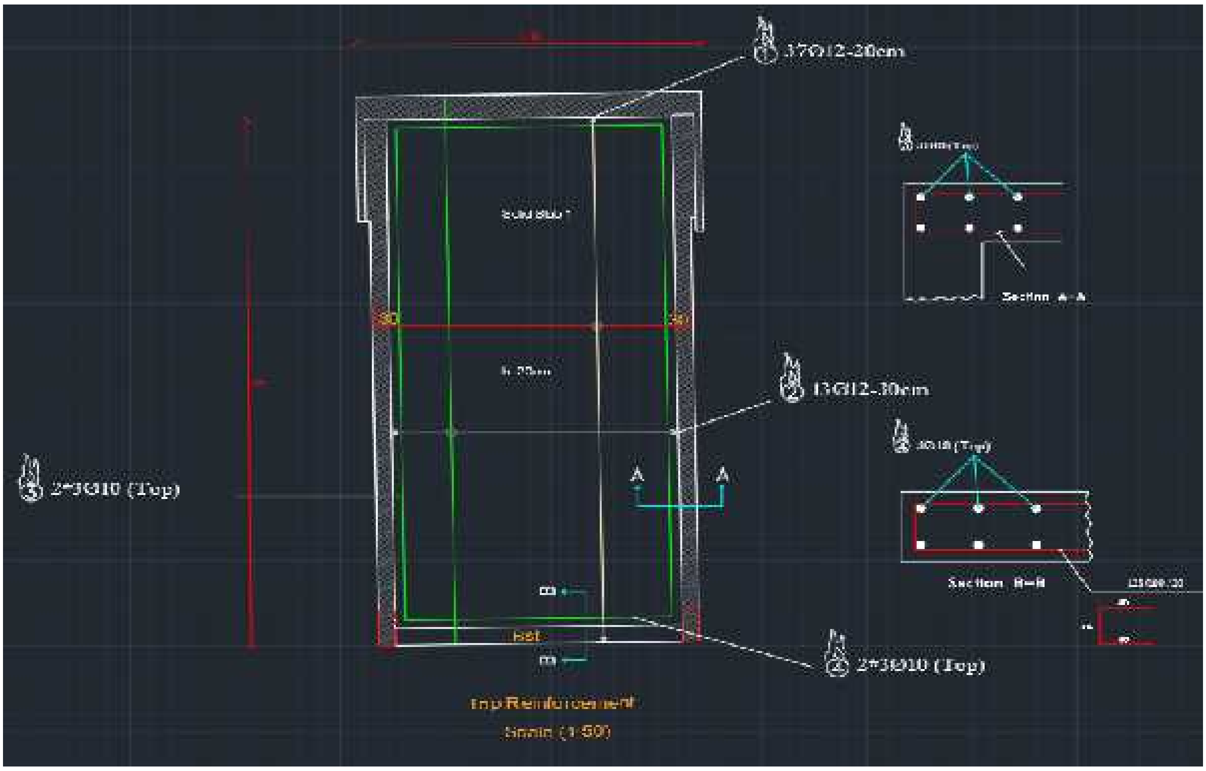


Figure ( ) stair slab(1) reinforcement

## 4.6 Design of rib R10as a reinforced concrete (T-Section)

Check of the selected dimensions.

- ht = 8cm
- bw = 12cm ≥ 10cm
- hr = 35 ≤ 3.5(12) = 42cm
- LC = 40 ≤ 75cm

✓ LoadCalculation: -

**1 -Dead Load: -**

| No. | Parts of Rib | Calculation |
|---|---|---|
| 1 | Tiles | 0.03*23*0.52 = 0.359 KN/m/rib |
| 2 | Mortar | 0.03*22*0.52 = 0.343 KN/m/rib |
| 3 | Coarse Sand | 0.07*17*0.52 = 0.62 KN/m/rib |
| 4 | Topping | 0.08*25*0.52 = 1.04 KN/m/rib |
| 5 | RC. Rib | 0.27*25*0.12 = 0.81 KN/m/rib |
| 6 | Hollow Block | 0.27*10*0.4 = 1.08 KN/m/rib |
| 7 | plaster | 0.03*22*.52= 0.343 KN/m/rib |
| 8 | partitions | 1.5*0.52= 0.78 KN/m/rib |
| | | Sum = 5. 895KN/m/rib |

**Table5: Dead Load Calculation of Rib**

**Reactions**

| Factored | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DeadR | 12.38 | 33.47 | 16.7 | 20.47 | 23.16 | 23.15 | 20.64 | 15.05 | 20.68 | 7.06 |
| LiveR | 4.76 | 12.32 | 8.97 | 9.27 | 9.39 | 9.34 | 8.71 | 7.28 | 7.89 | 2.89 |
| MaxR | 17.14 | 45.79 | 25.67 | 29.74 | 32.55 | 32.49 | 29.35 | 22.33 | 28.57 | 9.95 |
| MinR | 12.08 | 37.6 | 16.94 | 22.1 | 26.75 | 26.77 | 22.74 | 16.54 | 23.62 | 6.72 |
| Service | | | | | | | | | | |
| DeadR | 10.32 | 27.89 | 13.92 | 17.06 | 19.3 | 19.29 | 17.2 | 12.54 | 17.24 | 5.89 |
| LiveR | 2.97 | 7.7 | 5.61 | 5.8 | 5.87 | 5.84 | 5.44 | 4.55 | 4.93 | 1.81 |
| MaxR | 13.29 | 35.59 | 19.52 | 22.85 | 25.17 | 25.13 | 22.64 | 17.09 | 22.17 | 7.69 |
| MinR | 10.13 | 30.47 | 14.07 | 18.07 | 21.54 | 21.55 | 18.51 | 13.47 | 19.07 | 5.67 |

**Dead Load / rib** = 5.895 KN/m

**Live load = 5KN/m2**

**Live load /rib** =5 KN/m$^2$ × 0.52m = 2.6KN/m.

**Effective Flange Width (bE)**

$b_e$for T- section is the smallest of the following:

1 - $b_e$= L / 4 = 534.4/ 4 =133.6cm

2 - $b_e$= 12 + 16 t = 12 + 16 (8) = 140 cm

3 - be ≤ center to center spacing between adjacent beams =52cm

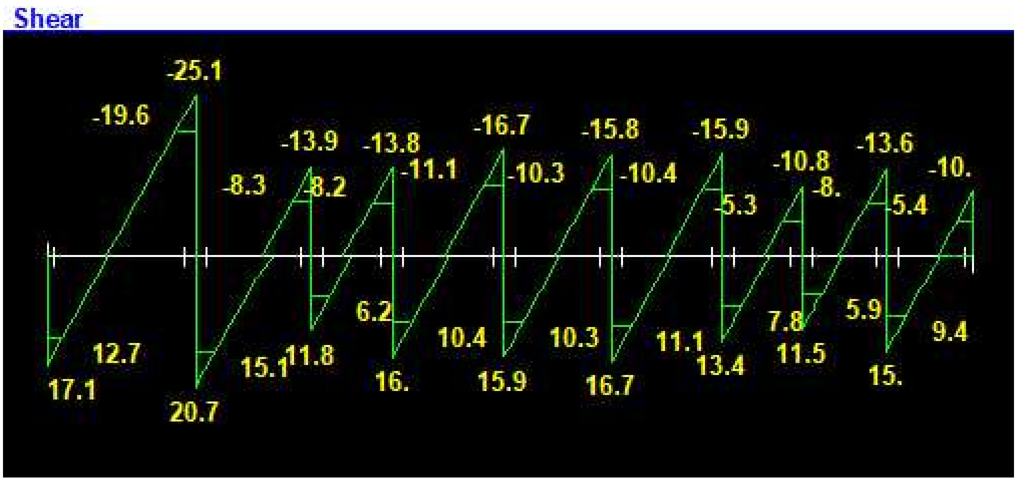
**Select (be ) for T-section = 52cm**

**Factored loads**

**Dead Load** = 1.2 * 5.895 +1.6 * 2.6 = 11.234KN /m

d = 350– 20 –10 – (12/2) = 314 mm

❖ **Design of Shear Force:**




**Picture 47: Shear envelope of Rib**

**Maximum (Vu) at the critical Section = 19.6 kN**

**1.1* Ø * Vn = 1.1 * Ø** *$\frac{1}{6} * \sqrt{f\acute{c}}$ ***bw*d** $\leq vu$=19.6KN

=1.1 *0.75 *$\frac{1}{6} * \sqrt{24}$ *120*314=25.38KN >VU =19.6KN

**So, shear reinforcement is required according to (ACI)**

**CASE 3:**

**Ø * Vc< Vu**$\leq \text{Ø} * Vc + \text{Ø} * Vs_{min}$

**Ø * Vc = 0.75***$\frac{1}{6} * \sqrt{f\acute{c}}$ ***bw*d** = 0.75*$\frac{1}{6} * \sqrt{24}$ *120*314=23.07KN

**Ø***$Vs_{min}$**=0.75***$\frac{1}{16} * \sqrt{f\acute{c}}$ ***bw*d**=0.75*$\frac{1}{16} * \sqrt{24}$ *120*314=8.65 KN

**OR**

**Ø** *$Vs_{min}$**=0.75***$\frac{1}{3}$ ***bw*d**=0.75*$\frac{1}{3}$ *120*314=9.4 KN… **Controlled**

**Ø * Vc + Ø *$Vs_{min}$ =23.07KN+9.4 KN=32.47KN>Vu =19.6KN**

**CASE 4:**

$\emptyset * \mathbf{Vc} + \emptyset * Vs_{min}$<Vu≤ $\emptyset * \mathbf{Vc} + \emptyset \frac{1}{3} * \sqrt{\mathbf{f\acute{c}}}$ ***bw*d**

**0.75***$\frac{1}{3} * \sqrt{\mathbf{f\acute{c}}}$ ***bw*d**=0.75*$\frac{1}{3} * \sqrt{24}$ *120*314=46.15 KN

$\emptyset * \mathbf{Vc} + \emptyset \frac{1}{3} * \sqrt{\mathbf{f\acute{c}}}$ ***bw*d**=23.07KN+46.15 KN=69.22KN>Vu=19.6KN

**Vs=**$\frac{Vu-\emptyset*Vc}{\emptyset}$=$\frac{19.6-23.07}{0.75} = 16.04\ KN$

**Av=# of legs*As**= 2*$\frac{\pi*8^2}{4}$ =100.53$mm^2$

$S_{req}$=$\frac{Av*fy*d}{Vs} = \frac{100.53*420*314}{16.04} = 826.6\ mm$

$$S_{req} \le \frac{d}{2} = \frac{314}{2} = 157 mm control$$

$$S_{req} \le 600mm$$

0.5 $\emptyset * \mathbf{Vc}$ <Vu $\le \emptyset * \mathbf{Vc}$

11.535 < 19.6 < 23.07

Avmin = 1/16 $\sqrt{\mathbf{f\acute{c}}}\frac{bw\ s}{fy} =$ .0625 $* \sqrt{24}$ *120*157/420 $=$ 13.74

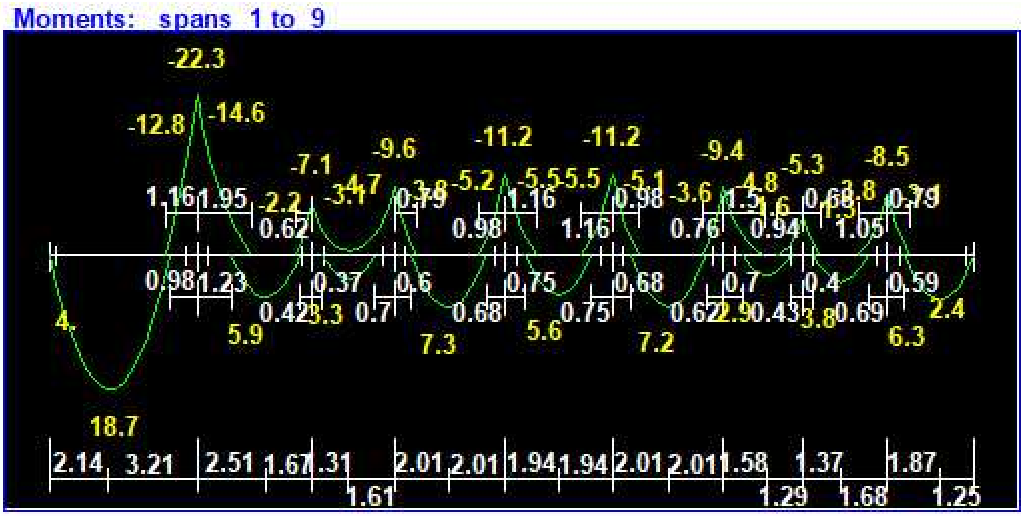
$$> \frac{1}{3}\frac{bw\ s}{fy} = 0.35 * 44.9 = 14.96$$

$$Avmin = 14.96mm2$$

Use 2 leg Φ 8 @ 155mm with Av =100.53mm2

## Select Ø8/15.5cm

- **Design of moment:**




**Picture 48: Moment envelope of Rib**

## Design positive moment:

### ✓ Design of positive moment in span (1)– Bottom Reinforcement:

**Span (1), maximum Mu = 18.7KN.m**

**Check (a ≤ t):**

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć * t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu+ = 18.7 kN.m **→ a< t**

## Design of rectangular section: (b = bE)

**Kn =** $\frac{Mu/Ø}{b*d^2} = \frac{18.7*10^6/0.9}{520*314^2} =$ 0.4053 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2 * Kn * m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 0.4053 * 20.6}{420}}\right) = 0.001$$

**As (req) = $\rho$ * bE *d** = 0.001 * 520 * 314 = 163.3 $mm^2$.

**<u>Check As(min):</u>**

**As (min)**= $\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ $mm^2$. …………« **<u>controlled</u>**

Or

**As (min)**= $0.25 * \frac{\sqrt{f\acute{c}}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 =$ 109.87 $mm^2$.

**So, As = 163.3 $mm^2$ > As (min) = 125.6 $mm^2$**

**→ Select 2 Ø12 with As = 226.2 $mm^2$.**

**<u>Check Strain:</u>**

T = C

As * Fy = 0.85 * Fc' * a * bE

226.2*420=0.85*24*a*520

a= 8.96 mm.

Since

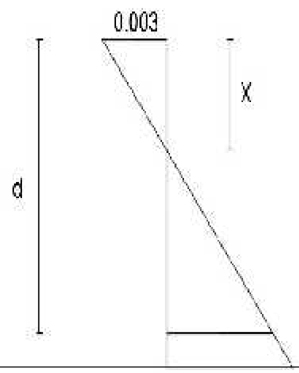
Fc' = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 8.96 / 0.85 = 10.54 mm

**<u>From Strain Diagram</u>**:

$$\frac{0.003}{10.54} = \frac{0.003 + \varepsilon s}{314}$$



$\varepsilon_s$=0.0864>0.005

So,

**Ø = 0.9 ……………… (OK)**

- ✓ **Design of positive moment in span (2) – Bottom Reinforcement:**

**Span (1), maximum Mu = 5.9KN.m**

**Check (a ≤ t):**

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć * t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu = 5.9 kN.m **→ a< t**

**Design of rectangular section: (b = bE)**

**KN =** $\frac{Mu/Ø}{b*d^2} = \frac{5.9*10^6/0.9}{520*314^2} =$ 0.13 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho=\frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right)=\frac{1}{20.6}\left(1-\sqrt{1-\frac{2*.13*20.6}{420}}\right)= 0.0003$$

**As (req) = $\rho$ * bE *d** = 0.0003 * 520 * 314 = 49.9 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 =$ 125.6 mm². « controll

Or

**As (min)=**$0.25 * \frac{\sqrt{f\acute{c}}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 =$ 109.87 mm².

**So, As = 49.9 mm² <As (min) = 125.6 mm²**

**→ Select 2 Ø10with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

157.1*420=0.85*24*a*520

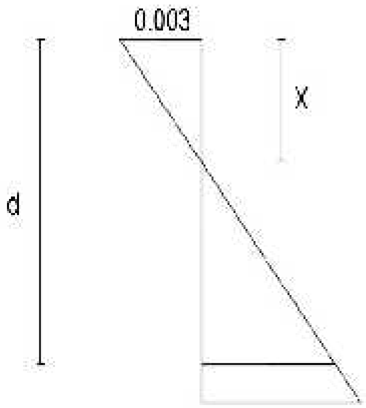
a= 6.22 mm.

Since

fc' = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm




**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$

$\varepsilon_s$=0.126>0.005

So,

**Ø = 0.9 …………… (OK)**

- ✓ **Design of positive moment in span (3) – Bottom Reinforcement:**

**Span (1), maximum Mu = 3.3KN.m**

**Check (a ≤ t):**

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć* t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu = 3.3kN.m **→ a< t**

**Design of rectangular section: (b = bE)**

**Kn =** $\frac{Mu/\text{Ø}}{b*d^2} = \frac{3.3*10^6/0.9}{520*314^2} =$ 0.072 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*0.072*20.6}{420}}\right) = 0.0002$$

**As (req) = $\rho$ * bE *d** = 0.0002 * 520 * 314 = 27.9 mm².

**Check As(min):**

As (min)=$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

As (min)=$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ mm².

**So, As = 27.9 mm² <As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

157.1*420=0.85*24*a*520

a= 6.22 mm.

Since

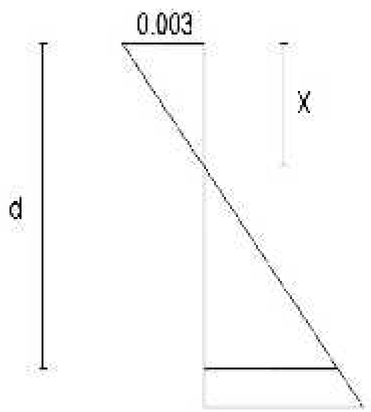
fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm

**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$




$\varepsilon_S$=0.13>0.005

So,

**Ø = 0.9 ……………..… (OK)**

## Design of negative moment:

Design as a rectangular section with (t =

120mm)

## Design of positive moment in span (3) – Bottom Reinforcement:

**Span (1), maximum Mu = 7.3KN.m**

**Check (a ≤ t):**

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć* t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu = 3.3kN.m **→ a < t**

**Design of rectangular section: (b = bE)**

**Kn =** $\frac{Mu/\text{Ø}}{b*d^2} = \frac{7.3*10^6/0.9}{520*314^2} = 0.16$ Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*0.16*20.6}{420}}\right) = 0.0003$$

**As (req) = $\rho$ * bE *d** = 0.0002 * 520 * 314 = 61.8 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=**$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ mm².

**So, As = 61.8 mm² <As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

**Check Strain:**

T = C

As * Fy = 0.85 * Fc’ * a * bE

157.1*420=0.85*24*a*520

a= 6.22 mm.

Since

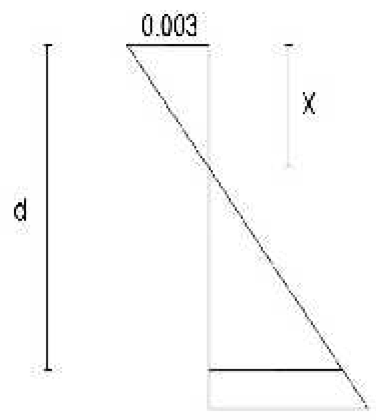
fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm

**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$




$\varepsilon_S$= 0.13>0.005

So,

**Ø = 0.9 ………………..… (OK)**

**Design of negative moment:**

Design as a rectangular section with (t = 120mm)

**Span (5), maximum Mu = 5.6KN.m**

**Check (a ≤ t):**

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć* t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu = 3.3kN.m **→ a < t**

**Design of rectangular section: (b = bE)**

**Kn =** $\frac{Mu/\varnothing}{b*d^2} = \frac{5.6*10^6/0.9}{520*314^2} = 0.12$ Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*0.12*20.6}{420}}\right) = 0.0002$$

**As (req) = $\rho$ * bE *d** = 0.0002 * 520 * 314 = 27.9 $mm^2$.

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ $mm^2$.« controll

Or

**As (min)=**$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ $mm^2$.

**So, As = 27.9 $mm^2$ <As (min) = 125.6 $mm^2$**

**→ Select 2 Ø10 with As = 157.1 $mm^2$**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

157.1*420=0.85*24*a*520

a= 6.22 mm.

Since

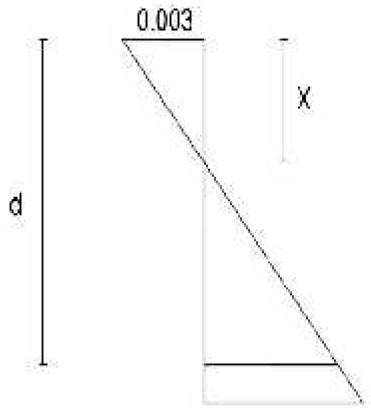
$f'_c$ = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm

**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$




$\varepsilon_s$= 0.13>0.005

So,

**Ø = 0.9 …………….…. (OK)**

## Design of negative moment:

Design as a rectangular section with (t = 120mm)

**Span (6), maximum Mu = 7.2KN.m**

**Check (a ≤ t):**

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * $f'_c$* t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu = 3.3kN.m **→ a < t**

**Design of rectangular section: (b = bE)**

**Kn =** $\frac{Mu/\text{Ø}}{b*d^2} = \frac{7.2*10^6/0.9}{520*314^2} =$ 0.16 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.16*20.6}{420}}\right) = 0.0003$$

**As (req) = $\rho$ * bE *d** = 0.0003 * 520 * 314 = 60.9 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=**$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ mm².

**So, As = 60.9 mm² <As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

157.1*420=0.85*24*a*520

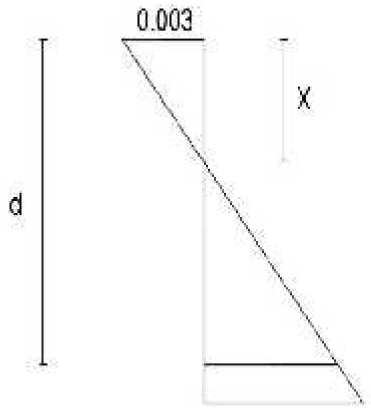
a= 6.22 mm.

Since

fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm




**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$

$\varepsilon_s$= 0.13>0.005

So,

**Ø = 0.9 ……………..…. (OK)**

## Design of negative moment:

Design as a rectangular section with (t = 120mm)

**Span (7), maximum Mu = 2.9KN.m**

**Check (a ≤ t):**

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć* t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu = 3.3kN.m **→ a < t**

**Design of rectangular section: (b = bE)**

**Kn =** $\frac{Mu/Ø}{b*d^2} = \frac{2.9*10^6/0.9}{520*314^2} = 0.063$ Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*0.063*20.6}{420}}\right) = 0.00015$$

**As (req) = $\rho$ * bE *d** = 0.00015 * 520 * 314 = 24.5 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=**$\mathbf{0.25 * \frac{\sqrt{fć}}{fy} * bw * d} = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ mm².

**So, As = 24.5 mm² <As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

157.1*420=0.85*24*a*520

a= 6.22 mm.

Since

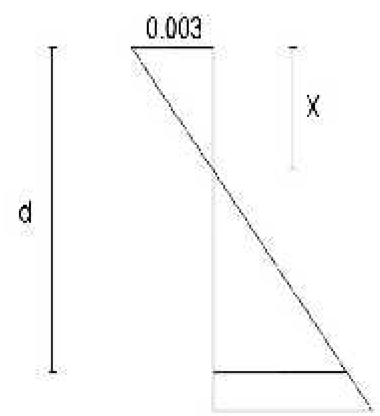
fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm

**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$




$\varepsilon_s$= 0.13>0.005

So,

**Ø = 0.9 ……………..…. (OK)**

## Design of negative moment:

Design as a rectangular section with (t = 120mm)

**Span (1), maximum Mu = 3.8KN.m**

**Check (a ≤ t):**

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć* t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu = 3.3kN.m **→ a < t**

**Design of rectangular section: (b = bE)**

**Kn =** $\frac{Mu/\text{Ø}}{b*d^2} = \frac{3.8*10^6/0.9}{520*314^2} = 0.083$ Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.072*20.6}{420}}\right) = 0.0002$$

**As (req) = $\rho$ * bE *d** = 0.0002 * 520 * 314 = 27.9 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=**$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ mm².

**So, As = 27.9 mm² <As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

157.1*420=0.85*24*a*520

a= 6.22 mm.

Since

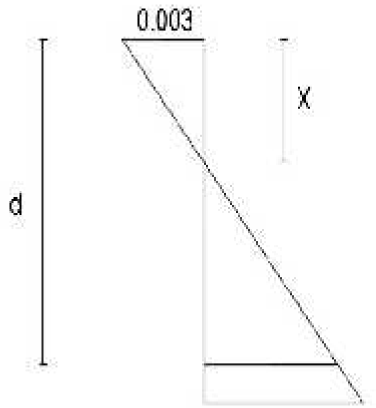
fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm

**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$




$\varepsilon_S$= 0.13>0.005

So,

**Ø = 0.9 ………………..… (OK)**

## Design of negative moment:

Design as a rectangular section with (t = 120mm)

**Span (9), maximum Mu = 2.4KN.m**

**Check (a ≤ t):**

Ø * Mn = Ø * C * (d – ½*t)

= 0.9 * (0.85 * fć* t * bE) * (314 - ½ * 80)

= 0.9 * 0.85 * 24 * 80 * 520 * (314 - ½ * 80)

= 209.27 kN.m > Mu = 3.3kN.m **→ a < t**

**Design of rectangular section: (b = bE)**

**Kn =** $\frac{Mu/\varnothing}{b*d^2} = \frac{2.4*10^6/0.9}{520*314^2} = 0.052$ Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*0.072*20.6}{420}}\right) = 0.00013$$

**As (req) = $\rho$ * bE *d** = 0.00013 * 520 * 314 = 20.3 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=**$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 = 109.87$ mm².

**So, As = 20.3 mm² <As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc’ * a * bE

157.1*420=0.85*24*a*520

a= 6.22 mm.

Since

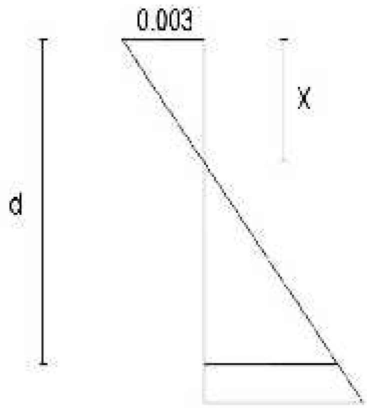
fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm

**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$




$\varepsilon_s$= 0.13>0.005

So,

**Ø = 0.9 ………………..… (OK)**

## Design of negative moment:

Design as a rectangular section with (t = 120mm)

- ✓ **Design of negative moment at support (B) – Top Reinforcement:**

**Support (B), minimum Mu = -22.3 kN.msection with bE = bw**

**Kn =** $\frac{Mu/\text{Ø}}{b*d^2} = \frac{22.3*10^6/0.9}{120*314^2} =$ 2.1 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*2.1*20.6}{420}}\right) = 0.0053$$

**As (req) = $\rho$ * bE *d** = 0.0053 * 120 * 314 = 198.7 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=**$0.25 * \frac{\sqrt{f\acute{c}}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 =$ 109.87 mm².

**So, As = 187.7 mm² > As (min) = 125.6 mm²**

**→ Select 2 Ø12 with As = 226.2 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

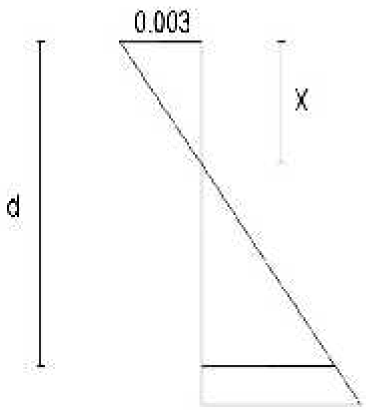
226.2*420=0.85*24*a*520

a= 8.95 mm.

Since f́c = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 8.95 / 0.85 = 10.54 mm




**From Strain Diagram:**

$$\frac{0.003}{10.54} = \frac{0.003 + \varepsilon s}{314}$$

$\varepsilon_s$ =0.087>0.005

So,

**Ø = 0.9 ……….….. (OK)**

✓ **<u>Design of negative moment at support (c) – Top Reinforcement:</u>**

**<u>Support (B), minimum Mu = -7.1 kN.m section with bE = bw</u>**

**KN =** $\frac{Mu/Ø}{b*d^2}=\frac{7.1*10^6/0.9}{120*314^2}=$ 0.67 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$\rho=\frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right)=\frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.67*20.6}{420}}\right)=$0.0017

**As (req) = $\rho$ * bE *d** = 0.0017* 120 * 314 = 60.9 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy}*bw*d=\frac{1.4}{420}*120*314=125.6$ mm².« controll

Or

**As (min)=**$0.25*\frac{\sqrt{fć}}{fy}*bw*d=0.25*\frac{\sqrt{24}}{420}*120*314=$ 109.87 mm².

**So, As = 60.9 mm² < As (min) = 109.87mm²**

**<u>→ Select 2 Ø10 with As = 157.1 mm²</u>**

**<u>Check Strain:</u>**

T = C

As * Fy = 0.85 * Fc' * a * bE

157.1*420=0.85*24*a*520

a= 6.22 mm.

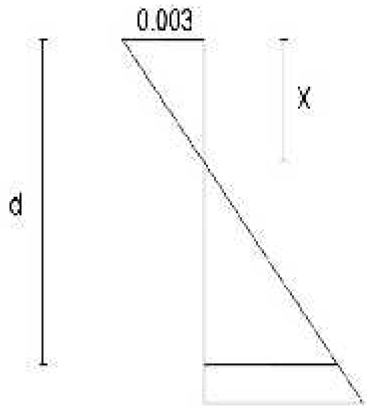
Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm

**From Strain Diagram:**

$$\frac{\mathbf{0.003}}{\mathbf{7.32}}=\frac{\mathbf{0.003+\varepsilon s}}{\mathbf{314}}$$




$\varepsilon_s$=0.13>0.005

So,

**Ø = 0.9 ……………. (OK)**

**minimum Mu = 9.6- kN.m section with bE = bw**

**Kn =** $\frac{Mu/\text{Ø}}{b*d^2}=\frac{9.6*10^6/\,0.9}{120*314^2}=$ .91 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho=\frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right)=\frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.91*20.6}{420}}\right)=0.0022$$

**As (req) = $\rho$ * bE *d** = 0.0022 * 120 * 314 = 82.8 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy}*bw*d=\frac{1.4}{420}*120*314=125.6$ mm².« controll

Or

**As (min)=** $\mathbf{0.25 * \frac{\sqrt{f\acute{c}}}{fy} * bw * d} = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 =$ 109.87 mm².

**So, As = 82.8 mm² < As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

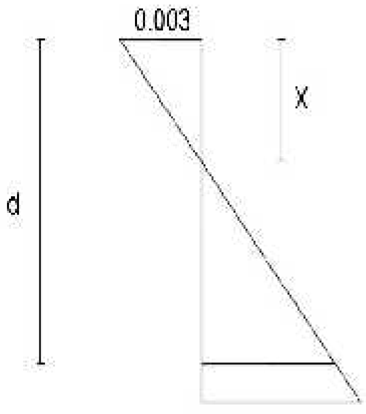
157.1*420=0.85*24*a*520

a= 6.22 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm




**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$

$\varepsilon_s =$ 0.13>0.005

So,

**Ø = 0.9 ……………. (OK)**

**minimum Mu = 11.2- kN.m section with bE = bw**

**Kn =** $\frac{Mu/\varnothing}{b*d^2} = \frac{11.2*10^6/0.9}{120*314^2} =$ 1.05 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*1.05*20.6}{420}}\right) =$ 0.0026

**As (req) =** $\rho$ *** bE *d** = 0.0026 * 120 * 314 = 96.94 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=**$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 =$ 109.87 mm².

**So, As = 96.94 mm² < As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc’ * a * bE

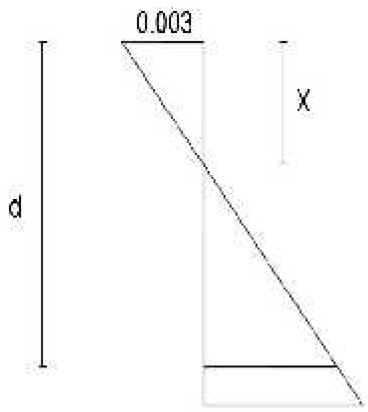
157.1*420=0.85*24*a*520

a= 6.22 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm




**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$

$\varepsilon_{s}$ = 0.13>0.005

So,

**Ø = 0.9 …………..… (OK)**

**minimum Mu = 9.4- kN.m    section with bE = bw**

**Kn =** $\frac{Mu/\,Ø}{b*d^2} = \frac{9.4*10^6/\,0.9}{120*314^2} =$ 0.88Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.91*20.6}{420}}\right) = 0.0022$$

**As (req) = $\rho$ * bE *d** = 0.0022 * 120 * 314 = 82.8 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=** $0.25 * \frac{\sqrt{f\acute{c}}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 =$ 109.87 mm².

**So, As = 82.8 mm² < As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

157.1*420=0.85*24*a*520

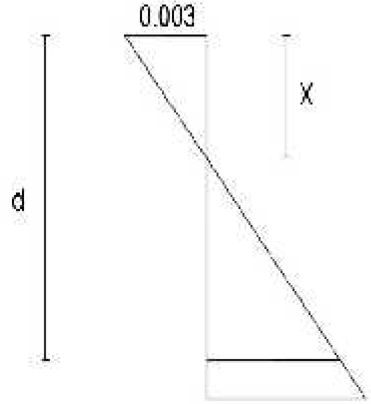
a= 6.22 mm.

Since $f\acute{c}$ = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm

**From Strain Diagram:**




$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$

$\varepsilon_s =$ 0.13>0.005

So,

**Ø = 0.9 …………..… (OK)**

**minimum Mu = 5.3- kN.m section with bE = bw**

**Kn =** $\frac{Mu/\varnothing}{b*d^2}$ = $\frac{5.3*10^6/0.9}{120*314^2}$ =0.5 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho=\frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right)=\frac{1}{20.6}\left(1-\sqrt{1-\frac{2*0.5*20.6}{420}}\right)=0.0012$$

**As (req) = $\rho$ * bE *d** = 0.0012 * 120 * 314 = 54.5 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy}*bw*d=\frac{1.4}{420}*120*314=125.6$ mm².« controll

Or

**As (min)=**$0.25*\frac{\sqrt{fć}}{fy}*bw*d=0.25*\frac{\sqrt{24}}{420}*120*314=$ 109.87 mm².

**So, As = 54.5 mm² < As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

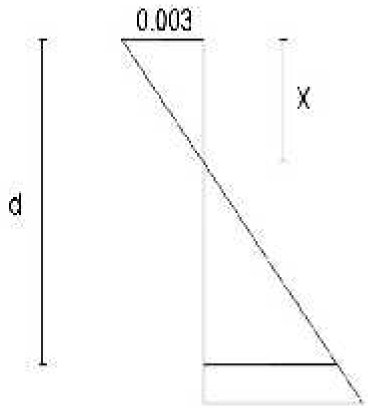
157.1*420=0.85*24*a*520

a= 6.22 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm




**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$

$\varepsilon_{S} =$ 0.13>0.005

So,

**Ø = 0.9 ……………. (OK)**

**minimum Mu = 9.6- kN.m section with bE = bw**

**Kn =** $\frac{Mu/\text{Ø}}{b*d^2} = \frac{9.6*10^6/0.9}{120*314^2} =$ .91 Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*0.91*20.6}{420}}\right) = 0.0022$$

**As (req) =** $\rho$ *** bE *d** = 0.0022 * 120 * 314 = 82.8 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=**$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 =$ 109.87 mm².

**So, As = 82.8 $mm^2$ < As (min) = 125.6 $mm^2$**

**→ Select 2 Ø10 with As = 157.1 $mm^2$**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

157.1*420=0.85*24*a*520

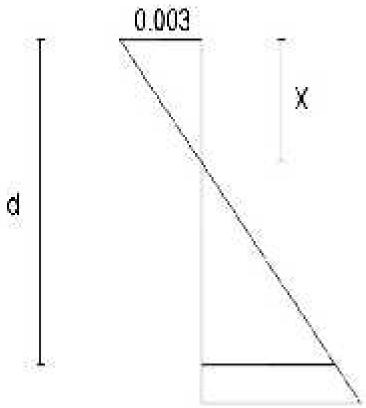
a= 6.22 mm.

Since $f\acute{c}$ = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm

**From Strain Diagram:**




$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$

$\varepsilon_s$ = 0.13>0.005

So,

**Ø = 0.9 ……………. (OK)**

**minimum Mu = 8.5- kN.m  section with bE = bw**

**Kn =** $\frac{Mu/\,Ø}{b*d^2} = \frac{8.5*10^6/\,0.9}{120*314^2} = 0.8$ Mpa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*00.8*20.6}{420}}\right) = 0.002$$

**As (req) = $\rho$ * bE *d** = 0.002 * 120 * 314 = 73.1 mm².

**Check As(min):**

**As (min)=**$\frac{1.4}{fy} * bw * d = \frac{1.4}{420} * 120 * 314 = 125.6$ mm².« controll

Or

**As (min)=**$0.25 * \frac{\sqrt{fć}}{fy} * bw * d = 0.25 * \frac{\sqrt{24}}{420} * 120 * 314 =$ 109.87 mm².

**So, As = 73.3 mm² < As (min) = 125.6 mm²**

**→ Select 2 Ø10 with As = 157.1 mm²**

## Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * bE

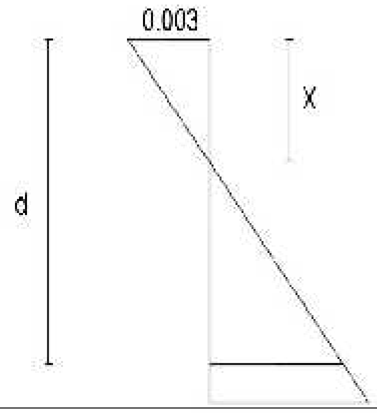
157.1*420=0.85*24*a*520

a= 6.22 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 6.22 / 0.85 = 7.32 mm



**From Strain Diagram:**

$$\frac{0.003}{7.32} = \frac{0.003 + \varepsilon s}{314}$$

$\varepsilon_s = 0.13 > 0.005$

So,

**Ø = 0.9 …………….. (OK)**

## 4.7 Design of Beam B1

**Load Calculations: -**

Dead Load Calculations for Beam The distributed Dead and Live loads acting upon Beam can be defined from the support reactions of the R3

**Dead Load: -**

| No. | Parts ofBeam | calculation |
|---|---|---|
| 1 | Tiles | 0.03*23*0.8 = 0.552 KN/m |

| | | |
|---|---|---|
| **2** | **Mortar** | **0.03*22*0.8 = 0.528 KN/m** |
| **3** | **Coarse Sand** | **0.07*17*0.8 = 0.952KN/m** |
| **5** | **RC. Beam** | **0.35*0.8*25 = 9 KN/m** |
| **7** | **Plaster** | **0.03*22*0.8 = 0.528 KN/m** |
| **8** | **Partitions** | 1.5***0.8= 2 KN/m** |

***Sum = 13.5KN/m***

**Table6: Dead Load Calculation of Beam**

Reactions

| Factored | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DeadR | 12.38 | 33.47 | 16.7 | 20.47 | 23.16 | 23.15 | 20.64 | 15.05 | 20.68 | 7.06 |
| LiveR | 4.76 | 12.32 | 8.97 | 9.27 | 9.39 | 9.34 | 8.71 | 7.28 | 7.89 | 2.89 |
| MaxR | 17.14 | 45.79 | 25.67 | 29.74 | 32.55 | 32.49 | 29.35 | 22.33 | 28.57 | 9.95 |
| MinR | 12.08 | 37.6 | 16.94 | 22.1 | 26.75 | 26.77 | 22.74 | 16.54 | 23.62 | 6.72 |
| Service | | | | | | | | | | |
| DeadR | 10.32 | 27.89 | 13.92 | 17.06 | 19.3 | 19.29 | 17.2 | 12.54 | 17.24 | 5.89 |
| LiveR | 2.97 | 7.7 | 5.61 | 5.8 | 5.87 | 5.84 | 5.44 | 4.55 | 4.93 | 1.81 |
| MaxR | 13.29 | 35.59 | 19.52 | 22.85 | 25.17 | 25.13 | 22.64 | 17.09 | 22.17 | 7.69 |
| MinR | 10.13 | 30.47 | 14.07 | 18.07 | 21.54 | 21.55 | 18.51 | 13.47 | 19.07 | 5.67 |

**Picture 49: Reaction of Rib 10**

**From Rib 3:**

DL = (32.73/ 0.52) = 62.94 KN / m

Total DL = 62.94 + 1.2 * 13.5 = 79.14KN / m

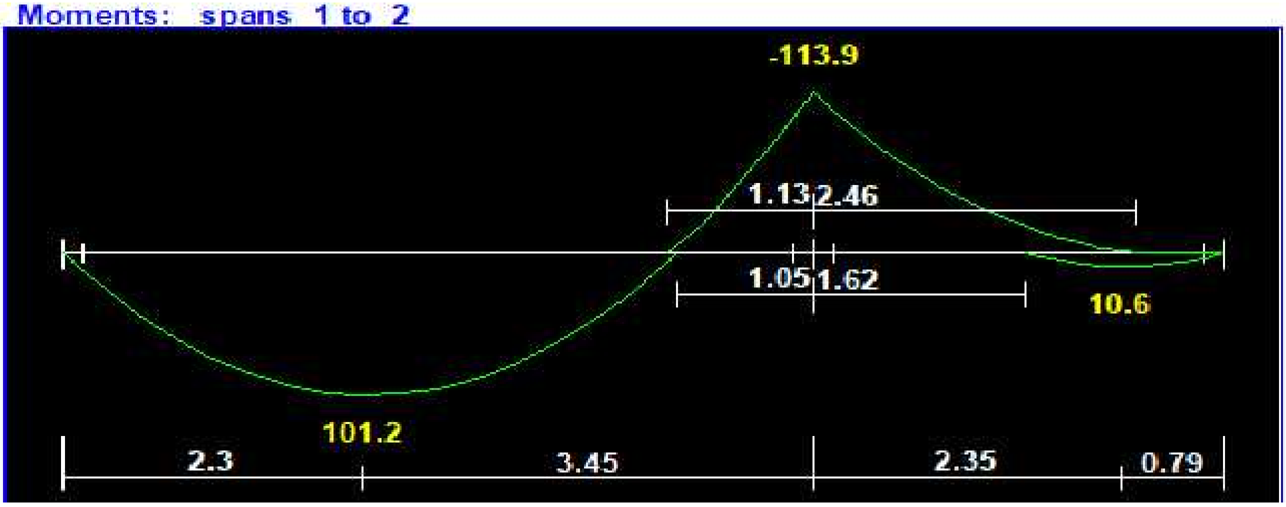
Live Load calculations for Beam: -

LL = 17.6 / 0.52 = 33.84 KN/m.

Nominal Total live load =5 * 0.8 = 4 KN/m

Total LL = 33.84 + 1.6 * 4 = 40.24 KN/m

## Design of moment for Beam:




**Picture 50: Moment of Envelope of Beam**

Reactions

| | | | |
|---|---|---|---|
| Factored | | | |
| DeadR | 67.13 | 171.83 | 16.64 |
| LiveR | 19.01 | 47.14 | 11.29 |
| MaxR | 86.15 | 218.97 | 27.93 |
| MinR | 66.54 | 185.9 | 9.92 |
| Service | | | |
| DeadR | 55.95 | 143.19 | 13.87 |
| LiveR | 11.88 | 29.46 | 7.05 |
| MaxR | 67.83 | 172.65 | 20.92 |
| MinR | 55.57 | 151.98 | 9.67 |

**Picture 51: Factored of Beam**

## ✓ Design of Positive Moment Mu = 101. 2KN.m

**Assume bar diameter ø 16 for main positivereinforcement**

d =350-40-10-12/2=294mm

**Kn =** $\frac{Mu/\varnothing}{b*d^2} = \frac{101.2*10^6/0.9}{800*294^2} = 1.63$ Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2*1.63*20.6}{420}}\right) = 0.00405$$

As (req) = $\rho$ * b *d = 0.00405 * 800 * 294 = 952.56 mm².

Check As(min):

As (min)=$\frac{1.4}{fy} * b * d = \frac{1.4}{420} * 800 * 294 = 784$ mm². « control

Or

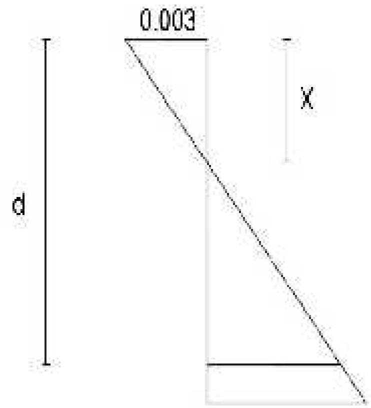
As (min)=0.25 $* \frac{\sqrt{fc'}}{fy} * b * d = 0.25 * \frac{\sqrt{24}}{420} * 800 * 294 = 685.86$ mm².

So, As = 952.65 mm² > As (min) = 784 mm²

As ø12 =113.1 mm²

$$N_{req} = \frac{AS_{req}}{AS\#\ BARS} = \frac{952.65}{113.1} = 8.42 basrs$$

**Select 10 ø 12 AS = 1130.97 mm²**




Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * b

1130.97*420=0.85*24*a*800

a= 29.12 mm.

Since fc' = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 29.12 / 0.85 = 34.24 mm

From Strain Diagram:

$$\frac{0.003}{34.24} = \frac{0.003 + \varepsilon s}{294}$$

$\varepsilon_s$=0.0227>0.005

So,

Ø = 0.9 … (OK)

- ✓ **Design of Positive Moment Mu = 10.6KN.m**

Assume bar diameter ø 12for main positivereinforcement

d =350-40-10-16/2=294mm

Kn = $\frac{Mu/\varnothing}{b*d^2} = \frac{10.6*10^6/0.9}{800*294^2} = 0.171$ Mpa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2 * Kn * m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 0.171 * 20.6}{420}}\right) = 0.00041$$

As (req) = $\rho$ * b *d = 0.00041* 800 * 392 = 96.5 mm².

Check As(min):

As (min)= $\frac{1.4}{fy} * b * d = \frac{1.4}{420} * 800 * 294 = 784$ mm².« controll

Or

As (min)= $0.25 * \frac{\sqrt{fc}}{fy} * b * d = 0.25 * \frac{\sqrt{24}}{420} * 800 * 294 = 685.86$ mm².

So, As = 96.5 mm² > As (min) = 784 mm²

As ø 12 =113.1 mm²

$$N_{req} = \frac{AS_{req}}{AS\# \, BARS} = \frac{784}{113.1} = 6.9 basrs$$

**Select 8ø 12 AS = 904.8 mm²**

Check Strain:

T = C

As * Fy = 0.85 * Fc' * a * b

904.8*420=0.85*24*a*800

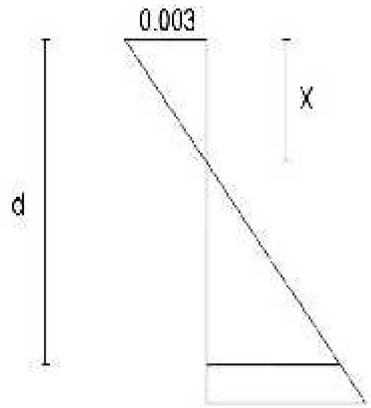
a= 23.3 mm.

Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 23.3/ 0.85 = 27.4 mm

From Strain Diagram:



$$\frac{0.003}{27.4} = \frac{0.003 + \varepsilon s}{294}$$

$\varepsilon_s$=0.029>0.005

So,

Ø = 0.9 … (OK)

## ✓ Design of Negative Moment Mu = - 113.9 KN.m

Assume bar diameter ø 12for main positivereinforcement

d =350-40-10-12/2=294mm

Kn = $\frac{Mu/\text{Ø}}{b*d^2} = \frac{113.9*10^6/0.9}{800*294^2} = 1.83$ MPa

m = Fy / (0.85* fć) = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*2.43*20.6}{420}}\right) = 0.0046$$

As (req) = $\rho$ * b *d = 0.0046* 800 * 294 = 1075.6mm².

Check As(min):

As (min)=$\frac{1.4}{fy} * b * d = \frac{1.4}{420} * 800 * 294 = 784$ mm².« controll

Or

As (min)=$0.25 * \frac{\sqrt{f\acute{c}}}{fy} * b * d = 0.25 * \frac{\sqrt{24}}{420} * 800 * 294 = 685.86$ mm².

So, As = 1075.6 mm² > As (min) = 784 mm²

As ø 12 =113.1 mm²

$$N_{req} = \frac{AS_{req}}{AS\# \ BARS} = \frac{1075.6}{113.1} = 9.6 \ basrs$$

**Select 10 ø 12 AS = 1130.97 mm²**

Check Strain:

T = C

As * Fy = 0.85 * Fc’ * a * b

1130.97*420=0.85*24*a*800

a= 29.12 mm.

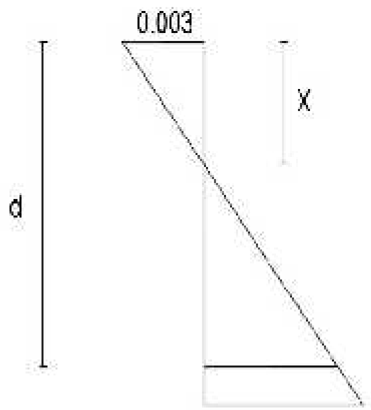
Since fć = 24 MPa < 28 MPa → β = 0.85

So,

X = a / β = 29.12/ 0.85 = 34.25mm

From Strain Diagram:

$$\frac{0.003}{34.25} = \frac{0.003 + \varepsilon s}{294}$$

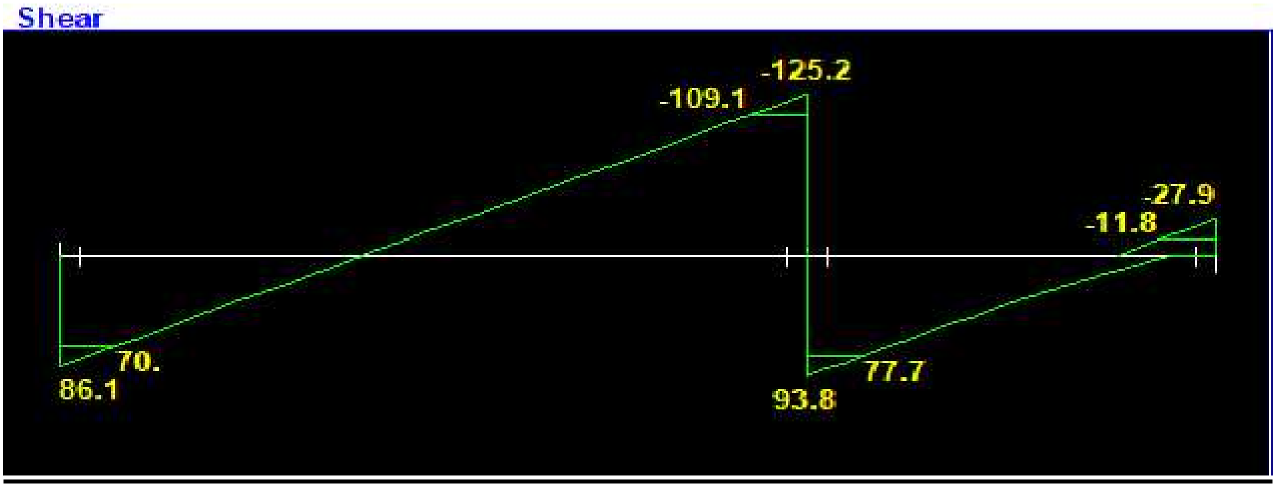



$\varepsilon_s$=0.023>0.005

So,

Ø = 0.9 … (OK)

## Design of shear for Beam




**Picture 57: Shear Envelope of Beam**

Vu = 109.1KN

d = 294KN

$Ø * Vc=0.75*\frac{1}{6}*\sqrt{f\acute{c}}*b*d=0.75*\frac{1}{6}*\sqrt{24}*800*294=144.03KN < Vu =109.1\ KN$

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).**

$V_c = \frac{1.1}{6}\ \sqrt{f_c'}b_w d = \frac{1.1}{6}\sqrt{24}\ \times 120 \times 294 \times 10^{-3} = 31.69\ KN$

$øV_c$ =0.75×31.69 =23.77 KN

0.5 ø $V_c$ =0.5×31.69 =15.88 KN

0.5 ø $V_c$< $V_u$< ø $V_c$

Case (2) for shear design, minimum shear reinforcement is required ($A_{v,min}$), exception for Ribbed slab , No shear Reinforcement .
Use stirrups U-shape as montage (4 leg stirrups ) ø8 @ 250 mm ,
$A_v$ = 4* 50.24 = 201.1 $mm^2$.

Vs = $(\frac{vc - ø\ Vc}{ø})$ =

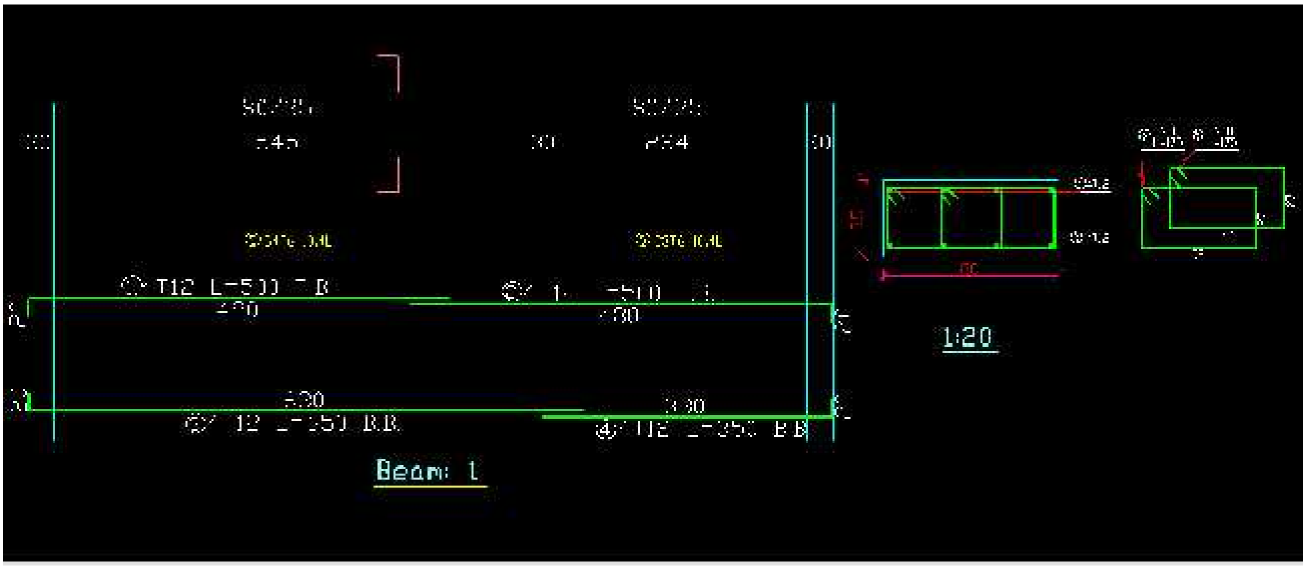
$(\frac{31.69-23.77}{0.75})$ = 10.6 KN

$$S = \frac{A_v f_{yt}\ d}{v_s} = \frac{201.1 * 420 * 294}{10.6 * 1000} = 2342.6\ mm$$

$$S_{req} \le \frac{d}{2} = \frac{294}{2} = 147 mm\, control$$

$$\le 600 mm$$

**Use 4 legs, 8@145$mm$**




## 4.8 Design of Column C46

**$f'_c = 24\ Mpa$ fy = 420 Mpa**

**Dead =236.18 KN Live =95.41 KN**

## Solution:

- **Check Slenderness:**

$$\frac{Klu}{r} \leq 34 - 12\left(\frac{m1}{m2}\right) \leq 40$$

About x & y axis
B = 50 cm , h = 30cm
K = 1 for braced
L= 2.75 m

$$\frac{1 * 3}{0.3 * 0.75} = 13.33 \leq 22 \leq 40$$

## Its Short Column in Both Direction

**Pu = 1.2*Dead +1.6*Live**
= 1.2*944.8+1.6*381.7 =1744.5KN

**Pu =**$\emptyset * 0.8\ \ 0.85 * fc'\ Ag - Ast\ \ + Ast * fy$

$\emptyset = 0.65\ for\ tied\ olumn$

Ag = 500 *300 =150000$mm^4$

1744.5 * $10^3$ $= 0.65 * 0.8 \{ 0.85 * 24\ \ 150000 - Ast\ \ + Ast * 420\}$

Ast = 737.76$mm^2$

$0.01 \leq \rho \leq 0.08$

$\rho = \frac{904.78}{150000} = 0.0063 < 0.01$ …………..**(not OK)**

0.02 = $\frac{As}{150000} =$

$As = 3000mm^2$

**Select 12$\emptyset$ 18 As = 3053.63$mm^2$ As longitudinal bars**

## Design for Ties:

Use Ø 10

1. **48*** $\boldsymbol{d_s}$ = 48*10 = 480 mm
2. **16***$\boldsymbol{d_b}$ = 16 *32 = 512 mm
3. **The least dimension of the column** = 300 mm

**Use ∅ 20@ 20cm as stirrups bars**

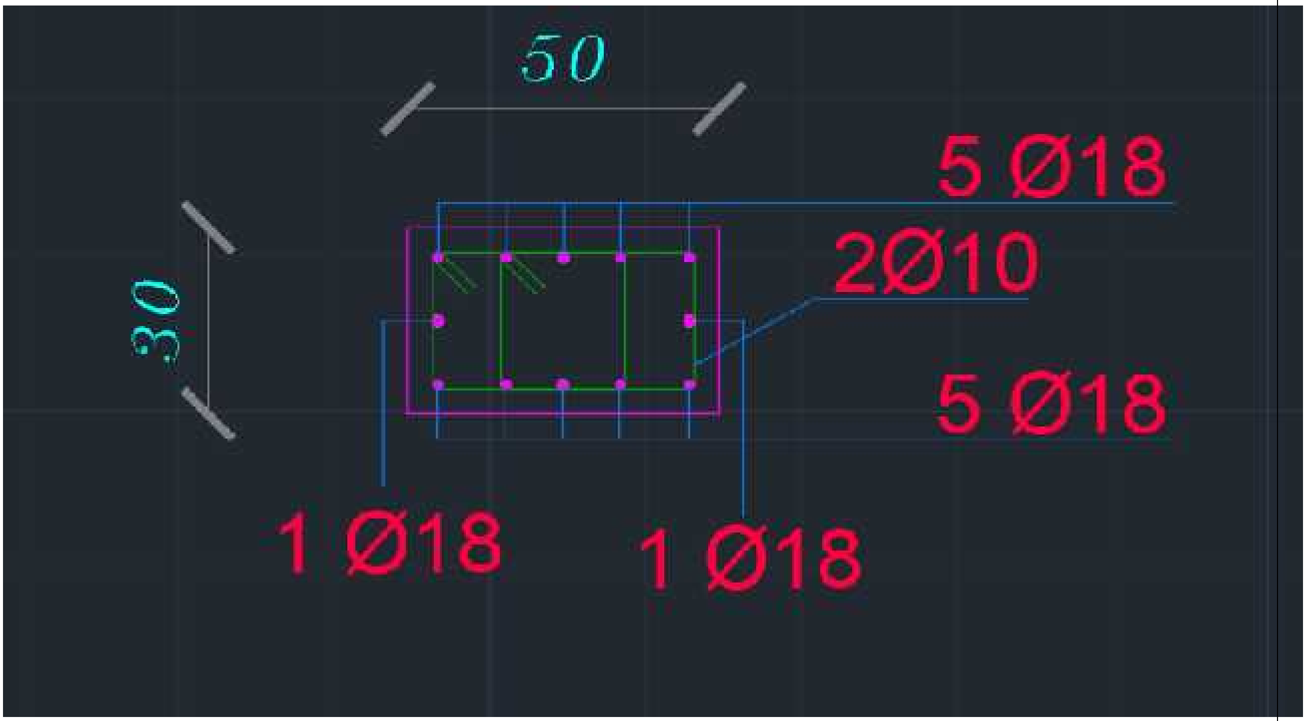
## Check code required

**1. Clear spacing between longitudinal bars:**

Clear spacing = $\frac{500-40*2-10*2-4*12}{3}$ = 117.33mm> 40mm ……… **(OK)**

**2. Gross reinforcement ratio:**

$$0.02 \le \rho \le 0.08$$




**Picture 54: Reinforcement of column**

## 4.9 Design of Footing F10

**Dead =944.8 KN** **Live =381.7 KN**

**Fy=420 Mpa** $f'c = 24\ Mpa$

$\gamma_{soil} = 17\ KN/m^3$ $\gamma_{RC} = 25\ KN/m^3$

# SOLUTION :

### Design of Bearing Pressure:

**Assume h=0.6 cm**

**FOR (1$m^2$) Under the footing:**

Live load = 5 $KN/m^2$

Weight of soil = 17*0.6 =10.2 $KN/m^2$

Weight of Footing =25*1.15 =15$KN/m^2$

**Net allowable bearing pressure ($\sigma_{b\,allow}$)** =500-5-10.2-28.75 =456.05 $KN/m^2$

$\sigma_{bu} = \frac{PU}{A} \leq 1.4 * \sigma_{b\,allow\,net}$

**PU = 1.2*Dead+1.6*Live** = 1.2*944.8+1.6*381.7 = 1744.5KN

$$\frac{1744.5}{a*a} = 1.4 * 456.05$$

a =1.653 m **a=1.8m**

**Bearing Pressure** $(\sigma_{bu}) = \frac{PU}{A} = \frac{1744.5}{1.8*1.8}$ = 538.5$KN/m^2$

## Design of one-way shear:

**Ø *vc =0.75 *$\frac{1}{6} * \sqrt{f\acute{c}}$ *b*d**

**d = h- cover - Ø** = 600 -75 -20 = 525 mm

**vu = $\sigma_{bu}$ *0.75*b**
=538.5*0.75*1.8 = 726.976 KN

Ø *vc =0.75 *$\frac{1}{6} * \sqrt{24}$ *1800*525
**= 578.7 KN < VU = 726.976 ……..(OK)**

## Design of Two-way shear:

d = 600 mm
bo =4*(600+500) =4400 mm
$\beta_c$ =1.0
$\alpha_s$= 40

**Ø *VC $\geq$ Vu**

**VU= Pu - $F_{RB}$**

= 1744.5 – 254.7*1.8*1.8

= 1286.04 KN

**Ø *VC** = 0.75* (2+ $\frac{4}{1}$ )*$\frac{\sqrt{24}}{12}$ *4400* 525 =4849.99 KN

**Ø *VC** = 0.75 *( $\frac{40*600}{4400}$ )*$\frac{\sqrt{24}}{12}$ *4400*525 = 4409.1 KN

**Ø *VC** = 0.75* $\frac{4}{12}$ *$\sqrt{24}$ *4400 * 525 = 3233.33 KN ……………... **Controlled**

**Ø *VC = 3233.33 KN>VU =** 726.976**KN ………. (OK)**

**h=0.6 m …………………….(OK)**

## Design of reinforcement (Bending Moment):

Mu: Factored internal resultant moment at the critical section at the face of column.

Mu = 603.64*1.6*1.1*0.55 =584.33 KN.m

**Design of rectangular section**

$$\frac{b}{d} = \frac{1800}{525} = 3.43$$

**Kn =** $\frac{Mu/Ø}{b*d^2} = \frac{584.33*10^6/0.9}{1800*525^2} = 1.3$ MPa

**m = Fy / (0.85* fć)** = 420 * (0.85*24) = 20.6

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*Kn*m}{fy}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*1.3*20.6}{420}}\right) = 0.0032$$

**As (req) = $\rho$ * b *d**= 0.0032× 180× 525 = 30.3$cm^2/total(a)$

**Check for minimum (As):**

As (min) for slabs and footings is As (min) for shrinkage and temperature

$Asmin$= **0.0018 × $b$ × h** = 0.0018 × 180 × 52.5 = 17.01$cm^2$

$Asreq$ **= 30.3$cm^2$ >$Asmin$ = 17.01$cm^2$** → $OK$#

**Select 20∅14 withAs =12 × 2. 54= 30.8 $cm^2$ inbothdirection**

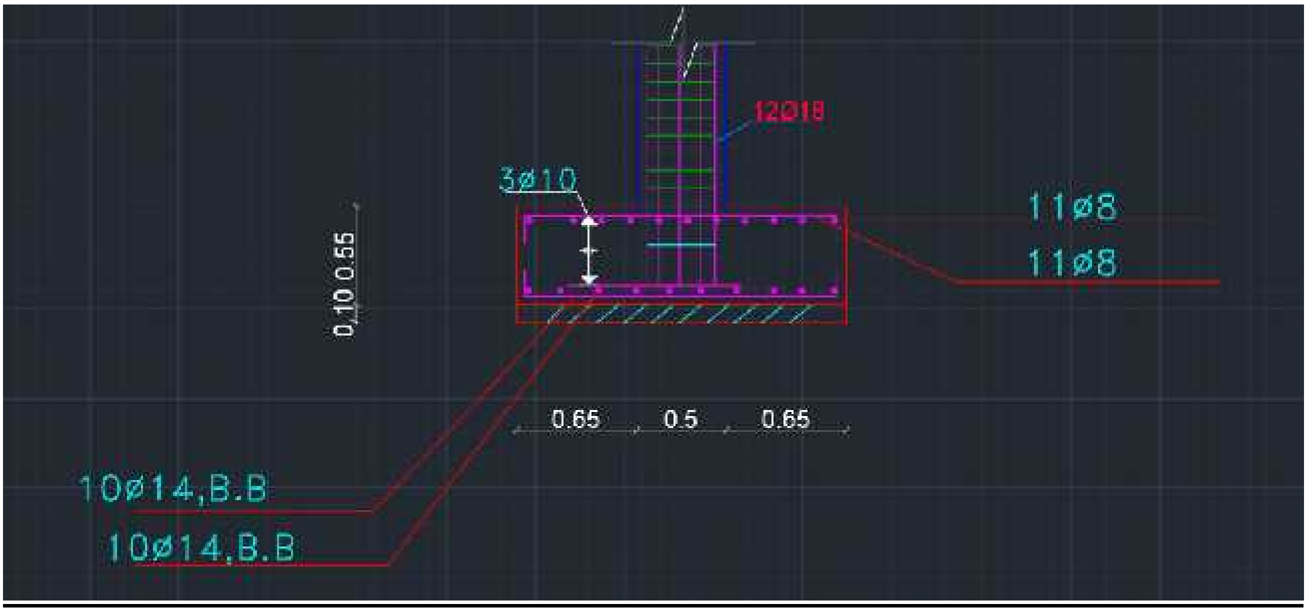
## - Design of Connection between column and footing:

**Design of bearing pressure at section of column (10)**

**× $Pnb$ = 0.65 × 0.85 × $fc'$ × $A1$ ≥ $P$u**

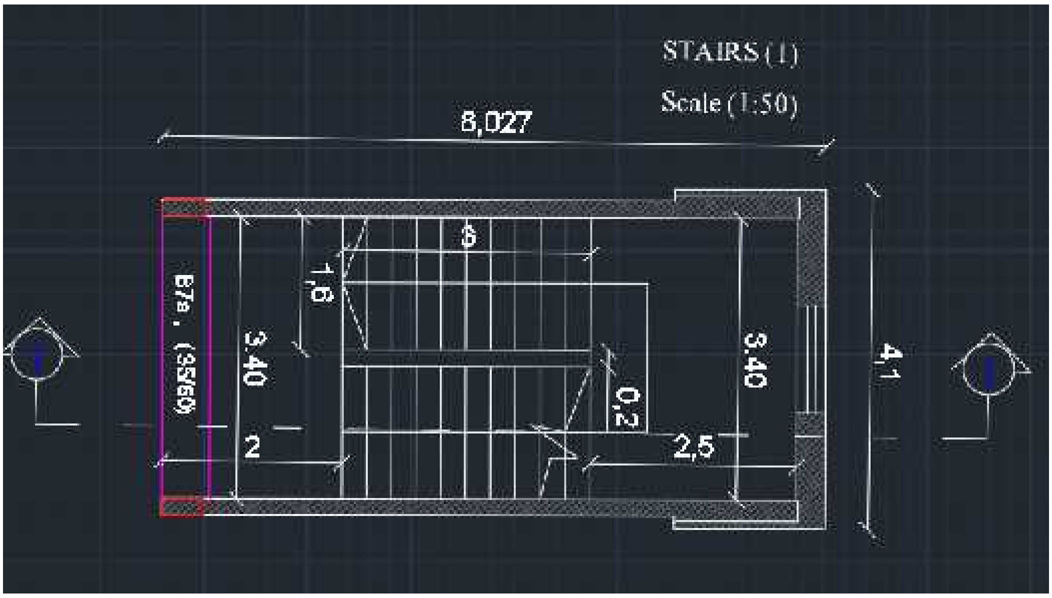
 × $Pnb$ = 0.65 × 0.85 × 24 × 300× 500= 1989KN >$Pu$ = 1744.5 KN

Load transfer between column and footing can be done through concrete alone!




**Picture 55: Reinforcement of Footing**

# 4.10 Design of stair



Figure(4-18) Stair Plan(2)

❖ **Material :-**

⇒ concrete B300 Fc' = 24 N/mm$^2$

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

⇒ Rise = 160 mm

⇒ Run= 300mm

⇒ L.L= 5 KN

## 4-8-1 Design of Flight :-

✓ **Determination of Thickness:-**

hmin = L/20 =8.027/20 = 40 cm

hmin = L/28 =8.027/28 = 28.6 cm

hmin = L/28 =8.027/24 = 33 cm

Take h = 40 cm

The Stair Slope by $\theta = \tan^{-1}(16 / 30) = 28.07$

**Table 4.6 :The Calculation of total Dead Load for Flight for 1m Strip of stair (2) :-**

| No. | Parts of Flight | Calculation | |
|---|---|---|---|
| 1 | Plastering | (0.03*22*1 )/ cos 28.07 = 0.747 Kn/m | |
| 2 | Mortar | ((0.3+0.16)*0.02*22 )/0.3= 0.674Kn/m | |
| 3 | Stair | 0.16*0.3*0.5*1*25 /0.3 = 2Kn/m | |
| 4 | R.C | (0.40*25*1) / cos28.07$^{o}$ = 11.3Kn/m | |
| 5 | Tiles | (0.35+0.16 ) * 0.03 * 23 /0.3 = 1.173Kn/m | |
| | | Sum | 15.89 Kn/m |

**Factor Total Dead load of Flight** q1 = 1.2 *D.L+1.6 *L.L = 1.2 * 15.89 + 1.6 * 5 = 27.068 KN/M .

**Table 4.7 : The Calculation of total Dead Load for Landing for 1m Strip of stair (2) :-**

| No. | Parts of Landing | Calculation | |
|---|---|---|---|
| 1 | Plastering | 22*0.03*1= 0.66Kn/m | |
| 2 | Mortar | 22*0.02*1= 0.44Kn/m | |
| 4 | R.C | 25*0.40*1= 10 Kn/m | |
| 5 | Tiles | 23*0.03*1= 0.69Kn/m | |
| | | Sum | 11.79 Kn/m |

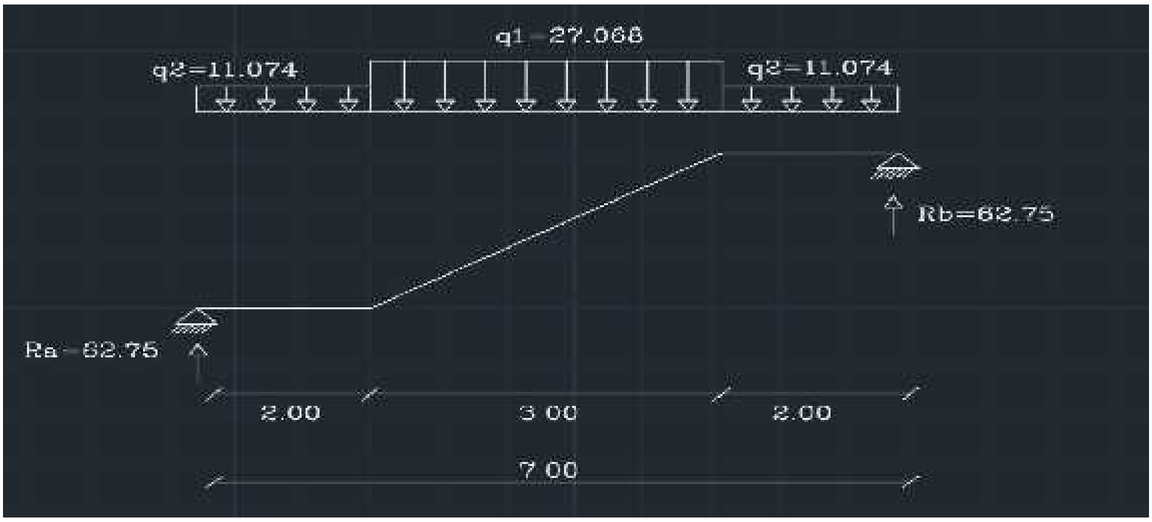
**Table ( 4-5 ):** Dead Load Calculation of Landing.

Live Load For Landing For 1m Strip = 5*1 = 5 Kn/m.

**Factored Load For landing :-**q2 = 1.2 ×11.79 + 1.6×5 = 22.148Kn/m .

## 4-7-2 Design of flexure of stair 1 .

**Because the load on landing is carried in to two direction , only half the load will be considered in each direction q= 22.148 / 2 = 11.074 kn.**




Figure(4.15) FLIGHT SYSTEM

Ra = (11.076 * 2 ) *2 + (27.068 * 3 ) = (125.5 / 2) = 62.75
Rb = 62.75

**Check for Shear Strength**
Assume Φ 14 bar for main reinforcement
D= h -20 – (db/2) = 400-20- 14/2 = 373 mm
Vu = 62.75 – 11.074 * (0.15 + 0.373) = 56.95 kn

$V_c = \frac{1}{6}\sqrt{fc'}b_w\,d = 0.16 * \sqrt{24} * 1000 * 373 * 10^{-3} = 304.55$ Kn

Φ Vc = 0.75 * 304.55 = 228.41
0.5 * Φ Vc = 0.5 *228.41 = 114.2
0.5 * Φ Vc = 114.2 > vu = 56.9 …. Ok
The Thickness is adequate enough .

## 4-7-3 Design The Maximum Bending Moment

Mu max = 62.75 * (7/2 ) – 11.074 * 2 * ( 2+3 /2 ) – 27.068 * (3/2) * (3/4) = 133.8kn
Mn = mu/ Φ = (133.8 / 0.9) = 148.6
Assume Φ 14 bar for main reinforcement

D= h -20 – (db/2) = 400-20- 14/2 = 373 mm

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

$R_n = \frac{M_n}{bd^2} = \frac{148.6 \times 10^6}{1000 \times 373^2} = 1.06\ MPA$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = 0.00259$

$A_{s,req}$ = ρ.b.d = 0.00259 ×1000×373 = 967.2 $mm^2$

$A_{s,min}$= 0.0018*1000*400 = 720$mm^2$

$As_{req}$ = 967.2 $mm^2$ > $A_{s,min}$=720$mm^2$ ….. OK

Use ø14

N = AS/ AS Φ14

N= (967.2 / 154 ) = 6.28

S= ( 1/n ) = S= 1/6.28

S= 0.159

**Take 7 Φ 14 /150 With As = 1078 $mm^2$**

**Check for Spacing :-**

S = 3h =3*400 = 1200 mm

S = 380*($\frac{280}{\frac{2}{3} * 420}$) – 2.5*14 = 345mm

S = 300*($\frac{280}{\frac{2}{3} * 420}$) = 300mm…….. control .

S= 150mm < Smax = 300mm ok

**<u>Use7 ø14 @ 150 mm ,$A_s$= 1078 $mm^2$</u>**

**Temperature and Shrinkage Reinforcement**

Take Φ 14

AS = 0.0018 *b* h = 0.0018 * 1000 * 400 = 720 $mm^2$

N = AS/ AS Φ14

N= (720 / 154 ) = 4.67

S= ( 1/n ) = S= 1/4.67

S= 0.21

Take 5 Φ 14 /200 With As = 770 $mm^2$

**Check for Spacing :-**

S = 5h =5*400 = 2000 mm

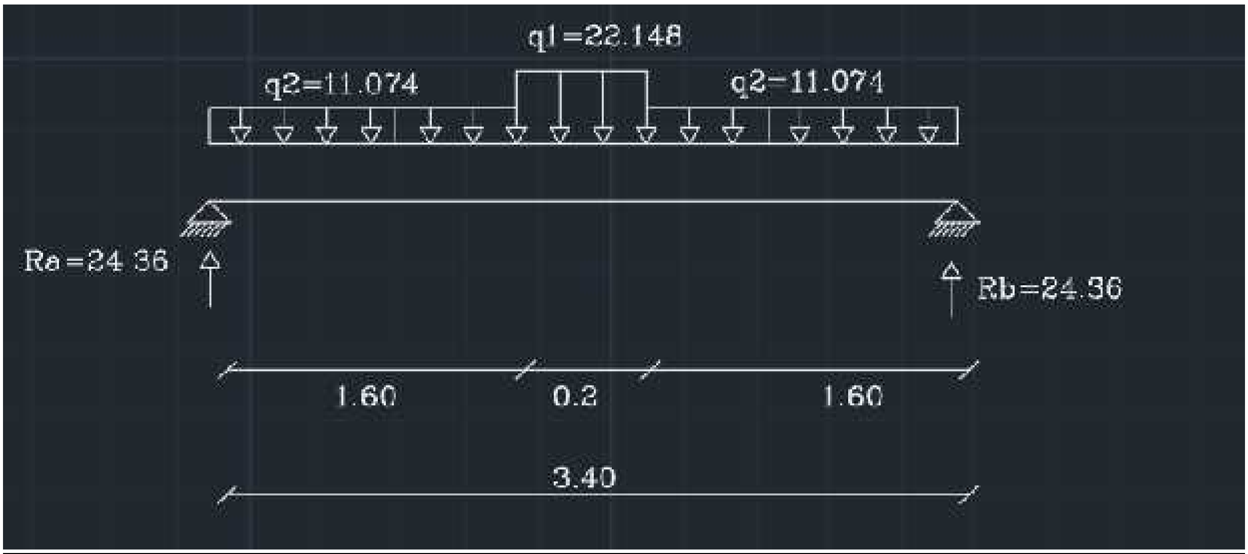
S = 380*($\frac{280}{\frac{2}{3} * 420}$) – 2.5*14 = 345mm

$S = 300*(\frac{280}{\frac{2}{3}*420}) = 300mm$…….. control .

S= 200 < Smax = 300 …..

**Use5 ø14 @ 200 mm ,$A_{s,}$= 770 mm$^2$**

## 4-7-4 Design of landing :




Figure(4.16) LANDING SYSTEM

Reaction = ( 11.076 *2 ) * 2 + ( 22.148 * 0.2 ) = (48.73/2 ) = 24.36

Mu = 24.36 * ( 3.40/2) – 11.076*1.6*( 1.6+0.2 /2) – 22.148 *(0.2/2) * (0.2/4)

Mu = 25.34

Mn = (Mu / Φ)

Mn = 25.34 / 0.9 = 28.15 kn.m

Assume Φ14

D= h -20 –14- (db/2) = 400-20-14- 14/2 = 359 mm

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

$$R_n= \frac{Mn}{bd^2} = \frac{28.15\times10^6}{1000\times359^2} = 0.218\ MPA$$

$$\rho= \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = 0.000517$$

$A_{s,req}$ = ρ.b.d = 0.000517 ×1000×359 = 185.6 mm$^2$

$A_{s,min}$= 0.0018*1000*400 = 720mm$^2$

$As_{req}$ = 185.6 mm$^2$ < $A_{s,min}$=720mm$^2$

Take AS min = 720mm$^2$

Use ø14

N = AS/ AS Φ14

N= (720 / 154 ) = 4.67

S= ( 1/n ) = S= 1/4.67

S= 0.21

**Take 5 Φ 14 /150 With As = 770 $mm^2$**

**Check for Spacing :-**

S = 3h =3*400 = 1200 mm

S = 380*($\frac{280}{\frac{2}{3}*420}$) – 2.5*14 = 345mm

S = 300*($\frac{280}{\frac{2}{3}*420}$) = 300mm…….. control .

S= 200mm < Smax = 300mm ok

**Use5 ø14 @ 150 mm ,$A_{s,}$= 770 > AS min = 720 $mm^2$ $mm^2$.**

**Picture 57: Reinforcement of stair**

## 4.11 Design ofShear wall

**Fć =24 Mpa Fy = 420 Mpa h = b = 20 cm**

**Lw = 3.7 m Hw =9.9 m**

## Design of horizontal Reinforcement:

**<u>Fx =Vu = 540 KN</u>**

Critical section of shear the smaller of:

$\frac{lw}{2} = \frac{3.7}{2}$ = 1.85 m ………… Controlled

$\frac{hw}{2} = \frac{9.9}{2}$ = 4.95 m

Story Hight (HW) = 3.3 m

**d = 0.8 *Lw** = 0.8* 3.7 = 2.96 m

## shear strength of concrete vc

**Vc =** $\frac{1}{6} * \sqrt{Fć}$ ***b *d** = $\frac{1}{6} * \sqrt{24}$ *200 *2960 = 483.4 KN …………(**Controlled)**

**Vc =** $\frac{\sqrt{Fć} * b * d}{4} + \frac{Nu * d}{4 * lw} = \frac{\sqrt{24} * 200 * 2960}{4} + \frac{0 * 2960}{4 * 3700}$ = 752.05 KN

**Vc =** $\left\{ \frac{\sqrt{Fć}}{2} + \frac{lw\left(\sqrt{Fć} + \frac{2NU}{Lw * h}\right)}{\frac{mu1}{vu} - \frac{lw}{2}} \right\} * \frac{h * d}{10}$

$= \frac{\sqrt{24}}{2} + \frac{3.7\left(\sqrt{24} + \frac{2 * 0}{3700 * 200}\right)}{\frac{3700}{950} - \frac{3.7}{2}} \} * \frac{200 * 2960}{10} =$ 669,81 KN

**<u>Vc = 483.4 KN</u>**

**<u>$(\emptyset * Vc)$ < VU ………………...Horizontal Reinforcement is required</u>**

*** Vc + *Vs = Vu**

**Vs = Vu/ - Vc** = 540/0.75 –483.4 = 236.6 kN

$\frac{Avh}{s} = \frac{Vs}{fy * d}$

$$\frac{\text{Avh}}{s} = \frac{236.6 * 1000}{420 * 2960} = 0.2$$

$$\frac{\textbf{Avh}}{s} = \mathbf{0.0025 * h} = 0.0025 * 200 = 0.5$$

$$\frac{\text{Avh}}{s} = 0.5 \qquad \textbf{is controlled}$$

**Smax = Lw/5** = 3700/5= 740 mm**………. controlled**

= **3*h** = 3*200 = 600 mm

**Select 12**

Avh = 2 legs * π/4 * $12^2$ = 226 $mm^2$
Avh /s = 0.5

**Sreq = Avh/0.5** = 226/0.5 = 452 mm
select S= 300 mm < Smax = 620mm **(Ok** )

**Select 10**

Avh = 2 legs * π/4 * $10^2$ =157 $mm^2$
Avh /s = 0.5

Sreq = Avh/0.5 = 157/0.5 = 314 mm
select S= 200 mm < Smax = 620mm (**Ok**)

## Design of uniform distributed vertical reinforcement:

**Avv = 0.0025 + 0.5 (2.5 – hw/Lw) *( Avh/(S horizontal*h) -0.0025 )* h *S**

Avv/s =( 0.0025 +0.5 (2.5 – 9.9/3.70) * (2*79 /( 200*200) – 0.0025) ) * 200

= 0.5

**Select 10, 2 layers**

Avv = 2*79 =157 mm$^2$

157/S = 0.5

S req = 314 mm

select S = 314 mm

**Smax = Lw/5** = 3700/5= 740 mm

**= 3*h** = 3*200 = 600 mm

= 600 mm **controlled**

S = 314 mm < 600 mm **………Ok**

## Design of Bending Moment:

**Mu = 3204 kNm**

**Mu = Muv + Mu boundary**

Asv = 2*79 * 3700/200 = 2923 mm$^2$

$$\frac{z}{Lw} = \frac{1}{2 + \frac{0.85*\beta*fc'*Lw*h}{Asv*fy}} = \frac{1}{2 + \frac{0.85*0.85*24*3700*200}{2923*420}} = 0.081$$

**Muv = 0.9 (0.5*Asv*fy*Lw*(1-** $\frac{z}{2Lw}$**)**

= 0.9 * (0.5 *2923*420*3700*(1-0.081/2)

**= 1961.3 KN.m< Mu = 3204 KN.m**

**Mub = Mu – Muv** = 3204-1961.3 = 1242.7 Kn

**X ≥ (Lw /(600 *Δu/hw))** = 3700/(600*0.0135) = 350.3mm

**LB ≥ X/2** = 450.3 /2 = 225.15 mm

≥ **x-0.1*Lw** = 450.3-0.1*3700 = mm

**Select LB=20cm**

**$A_{SB}$ = MuB* /(fy*(Lw-LB))**
= 1242.7* 0.9 / (420(3700-200)
= 1988.7 $mm^2$

**Select 10 16 with As =2010.61 $mm^2$**

# Chapter 5
# Outcomes and Recommendations

- **5.1 Introduction**
- **5.2 Outcomes**
- **5. 3 Recommendations**
- **5. 4 Reference**

## 5.1 Introduction

In this project, architectural plans were obtained that lack a lot of things. After studying all the requirements, architectural plans and comprehensive structural plans for the college proposed to be built were prepared.

Some construction plans were prepared in a detailed, accurate and clear manner to facilitate the construction process. This report provides an explanation of all the architectural and structural design steps of the building

## 5.2 Outcomes

- Every student in the work team will be able to design the structural elements manually so that they have sufficient experience and knowledge in using computerized designprograms.

- Among the factors that we must take are the natural factors surrounding the building such as wind, rain, snow, the nature of the site and the impact of natural forces on it, such asearthquakes.

- Through what we have done from the design of the building, we must take a comprehensive view of the building to link the various structural elements and then divide these elements to design them individually and know how to design taking into account the surroundingcircumstances.

- In this project, the one-way ribbed system was used and two-way ribbed slab in the building, drops beams were used due to the nature and shape of the building.Solid Slab has also been used in the staircase slabs and cars' parking because they are more effective than nerve nodes in carrying concentrated loads.

– The computer programmers that used are:

A – Microsoft office programs

B – AutoCAD program

C – Atir program

## 5. 3 Recommendations

This project worked to clarify and expand our understanding of the nature of construction projects, including the details, designs, architectural and construction analyzes.

From this experience we want to present a set of important recommendations:

- To obtain comprehensive information about the nature of the site, its soil and its durability, through an examination and a report specific to thatregion.

- The architectural design should be chosen and then all architectural and Construction plans are coordinated andprepared.

- At this stage, the appropriate structural system must be chosen in the construction process, such as a structural system or a system of load-bearing walls of reinforced concrete and stonefaces.

- A complete agreement and coordination must be found between the civil engineer and the architectural designer. The structural engineer must design the structural elements according to the plans. He must design a structural system that is resistant to vertical loads and horizontal forces caused by wind and earthquake loads.

- The electrical and mechanical design of the project must be completed before starting in a worksite to make any possible modifications to the project from a structuralpoint.

## 5. 4 Reference

1 – ACI – 318 16 ‘’ American Code ‘’

2 - Jordan Code

3 – Reinforced concrete I, II ‘’ DR. Nasser Abboshi’’ &Dr. Maher Amro

4- Wikiped