ULK POLYTECHNIC INSTITUTE (ULK)

DEPARTMENT OF CIVIL ENGINEERING

OPTION: CONSTRUCTION TECHNOLOGY

ACADEMIC YEAR: 2023-2024

STRUCTURAL DESIGN OF G+1 GYMNASIUM

CASE STUDY: ULK UNIVERSITY

Submitted in partial fulfilment of the requirements for the Award of advanced diploma in construction technology.

Presented by:

Nsengimana Sedoki

Rol Number: 202150079

Under the guidance of:

Eng. Munyabarame James

Kigali September 2024

DECLARATION

I hereby declare that project entitled **"**Architectural and structural design of G+1 gymnasium in ULK Kigali**"** is my original work submitted for the requirement of the award of advanced diploma in civil Engineering, Construction Technology in high learning institution and has never been presented and submitted for academic award in any other college, University or institution as a whole.

Names: Nsengimana Sedoki

Roll number: 202150079

Signature…………………

Date of submission…………...

APPROVAL

This is to certify that this project work entered" Architectural and Structural Design Of G+1 Gymnasium in Ulk Kigali" is an original work conducted by Nsengimana Sedoki under my supervision and guidance.

Name: Eng. Munyabarame James

Submission Date: ………/………/……………

Names of H.O.D: Eng. Nkiranuye Bonaventure

Signature ………………….

DEDICATION

I dedicate this project:

- To almighty God.
- To ULK Polytechnic staff and all lectures.
- To my supervisor Munyabarame James.
- To my parents for their supports.
- To my classmates and my families.
- To my relatives and friends for being on my side.

ACKNOLEDGEMENT

Firstly, my special thanks to almighty God for protecting and guiding us in all steps of my lives. Other thanks are addressed to the government of Rwanda through the ministry of education to provide the opportunity for Rwanda polytechnic to support the technical skills and knowledge related to the civil engineering.

I would like to thank ULK Polytechnic entire staff, in particular to the department of Civil Engineering for their combination efforts. my sincere gratitude goes to my supervisor Munyabarame James, for giving us an opportunity to work under his guidance and his technical wide advice, suggestions and collections that made this project perfect.

Finally, I express my gratitude to my families for their support, engagement and facilities throughout my studies great thanks goes to my parents. Thanks also to my classmate for their team works and support that make my dream to become true.

My God bless you all.

ABSTRACT

This research project entitled **"**Structural Design Of G+1 Gymnasium in Ulk Kigali" This research carries out the analysis of the structural elements such as the design of beam, slab, column, foundation and stair which was considered in this project and determine the capacity of my gymnasium where it will be able to accommodate 1300 people and also, we have to look about ventilation system that will provide fresh air at the gymnasium.

To achieve the above objectives, the inputs data including structural loadings and architectural drawings (dead loads) were entered and processed through software like archiCAD22 and AutoCAD to produce in details all architectural drawings, and Etabs for analysis of maximum moment and shear on the structural element for Concrete Frames (Beams & Columns) and Prokon for Slab and Footing. Methods from knowledge to analyze and calculating the structural elements such as reinforcement, quantity of items, checking safety for soil if it is able to resist to the super structural element.

It was concluded that the design of gymnasium was a very careful task to achieve because each structure member was designed at their most critically loaded areas to provide the maximum safety resistance and serviceability of such public building.

The results showed that the designed steel reinforcements to be arranged in slab l5T12@200 C/C and 3T10 @250 C/C at the bottom while for T beam designed steel reinforcements were 6T20@47 C/C at the top and 7T16@28 C/C at the bottom another L beam designed steel reinforcement were 2T8@273 C/C at the top and 2T8@280 C/C at the bottom. And for column the designed steel reinforcement was 5T25@250C/C for ground floor part the column and T8@200 C/C for first floor, second for the designed steel reinforcement were 6T16@100 C/C and 6T16 @ 100 C/C, for the stair designed steel reinforcement were 8T10@260C/C for main and 6T8@160 C/C.

Key words: Structural design, reinforced concrete building, Description of gymnasium Infrastructure

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF SYMBOLS, ACRONYMS AND ABBREVIATIONS

1. Symbols

Ac: Area of concrete

Asmin: Minimum area of steel

Asprov: Area of steel provided

Asreq: Minimum area steel required

As: Steel reinforcement

Asc: Minimum area of steel in compression

d: Depth

b: Effective breadth

bw: web width of flanged beam

Ly: Long span

Lx; Short span

Fcu: Design strength of concrete

Fy: Yield stress of steel

M: Applied moment

MR; Resisting moment

E: Modulus of elasticity

GK: Dead load

QK: Imposed load

L: Span

MF: Modification factor

N: Design axial load

Msx, Msy: Moment in short and long span

Bsx, Bsy: Moment coefficient in short and long span

Vsx, Bvy: Shear coeffient in short and long span

V: Nominal shear

V: Design shear

Vc: Shear capacity

B: Coefficient of end connection

2. ABBREVIATIONS

BS: British standard

C C: Critical column

C S: Critical slab

C B: Critical beam

LS: Lump sum

HOD: Head of Department

FIBA: The International Basketball Federation

TABLE OF CONTENTS

CHAPTER 1: GENERAL INTRODUCTION

1.0. Introduction

This Chapter provide a comprehensive background of the study, the problem statement, the main objectives, the specific objectives, the significance of the study, scope and limitations and the organization structure for all chapters

1.1 Background of The Study

Gymnasium is athletics building sports or room designed and equipped for indoor sports or physical training where people can entertain and assembly comfortable in different sectors by using machines for physical development training, to do physical exercises and their competitions especially basketball, volley ball, tennis and music concerts. (Lumpkin, Angela, 2013)

Ulk Kigali is the higher learning institution in which the sports activities and cultures are being at high level. Both volleyball and basketball disciplines are more likely developed as their volley ball team and basketball are in first National Division. These sports disciplines both requires sportive facility and infrastructures including Gymnasium. The conduction of this study has been decided because there are poor sports facilities in campus that are not fit the physical appearance and aesthetic of other existing structure. This will help to provide wide and better place for fitness workout to the people lives in this area including students and staff members.

To get the most out of gym, the layout of design needs to be precise planned, offering safety, efficiency and aesthetics. Choosing the right gymnasium floor for multi-use applications and reduce transition time and improve the functional facility. (Heinz, 2017)

1.2 Problem Statement

Due to lack of sports facility and lack of enough comfort, some competitions and training could not be performed at desired time in case of too much raining or sunny seasons, the idea of gymnasium is efficient and promising. Actually, most competitions like volleyball, basketball, tennis and other physical work out that were planned in rainy season will never took place because the spectators were unease standing in rain, this also to the applies to hot sunny days where people cannot stand comfortable because there no shade to shield them from the sunny.

After noticing all those issues that had a big negative effect on the performances of ULK Kigali sports teams and colleges reputations sports wise as well there was the process of conducting that project of structural design of G+1 Gymnasium in ULK Kigali, this will bring the positive effects and their solutions to that problems that have been mentioned above.

1.3 Objectives of The Project

1.3.1 Main Objectives

The main objective of this study is to make the architectural and structural design of G+1 Gymnasium in Ulk Kigali.

1.3.2 Specific Objectives

The following specific objectives are proposed to achieve the main objective of this project.

- To produce architecture drawing.
- To produce structure design of elements like slab, beam, columns, footing and foundation.
- To produce cost estimation.

1.4 Research Questions

1. How can the gymnasium's architectural design be optimized to support a variety of fitness activities while ensuring efficient space utilization and user comfort?

2. What structural systems and materials are best suited for the gymnasium to ensure safety, durability, and cost-effectiveness, considering the local climate and seismic conditions?

3. How can the gymnasium design incorporate sustainable practices, such as energy efficiency and environmentally friendly materials, while remaining within budget constraints?

4. What are the specific accessibility and inclusivity requirements for the gymnasium to ensure it meets the needs of all potential users, including those with disabilities?

1.5 Scope and Limitation of the Study

This research of architectural and structural design of gymnasium of G+1 it takes place at Gasabo District, GISOZI Sector in ULK Kigali and it deal with to focus on structural design and architectural drawings, sections, elevations and perspectives and in order to have comfortable building, structural analysis and design of all structural elements of gymnasium is done to provide required stability and cost of the building.

1.5.2 Limitation of The Study

This project is limited to the following works such as:

- Construction of designed gymnasium
- Wind effect test
- Earthquake analysis test
- Laboratory test
- Time

1.6. Significance of the study

1.6.1. Personal Interest of The Project

At the end of this project, us students we are able to use engineering software like ArchiCAD, AutoCAD and prokon software and other Microsoft such as word, excel and PowerPoint. Also, we are get knowledge about the design of structure members and calculation of quantities of materials and their estimated cost.

1.6.2. Academic Interest of The Project

Rwanda polytechnic especially Ulk Kigali are able in the cmyse of the qualified knowledge of their graduates, this study is also served as supportive reference to the future students of Ulk Kigali. While this study implemented, is also important to for Ulk Kigali improving new talents especially in basketball, volley ball, and other sectors mainly focus on fitness work out as they give more comfortable and also this will give remarkable aesthetic to Ulk Kigali.

1.6.3 Public Interest of The Project

The government of Rwanda is benefit in this project to host competition which may include local or international teams, this also improve the reputation of Rwanda in sports. The organization having sports as obligations will have no hard time of planning and putting these events and competitions into actions.

1.7 Organization of The Study

This research is divided into five chapters:

Chapter 1: General introduction that introduces the background of the study, the research problem, the objectives, the choices or interest of the project, scope, Methodology and organization of research or study.

Chapter 2: Explains Literature review of different things, which were concerned in the research like analyze architectural and structural design of Gymnasium of G+1

Chapter 3: Describes the Methodology used to determine data collected and analysis to research on results or objectives.

Chapter 4: shows the data analysis and representation: this chapter focuses on the calculation and analysis of structural elements (slab, beam, column and foundation).

Chapter 5: presents the research conclusion and recommendations, this chapter deals with the closing of the project by giving advices and recommendation to the people who will use this book.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A gymnasium is a building used to play indoor team sports such as basketball, volleyball and tennis. These halls are equipped with scoreboards to display game information (scorers, timer, faults,). (Angela, 2013)

The gymnasium is to be located in Ulk Kigali behind Ulk Kigali stadium, in Ulk Kigali city, Gasabo district, and Gisozi sector. My purpose is to use when the planned plot according to the Ulk Kigali master plan with regard to the comfort ability of gymnasium users.

2.2 planning

Is the process of thinking about the activity required to achieve a desired goal? It is the first and foremost activity to achieve desired result. It involves the creation and maintenance of a plan, such as psychological aspect that required conceptual skills (Shallice, 1982).

2.2.1 Principles of Building Planning

The main objective of planning a building is to ensure that the difference components of building are so arranged that occupants can perform desired function with ease and comfort. Good planning also requires that the entire are available within the building is gainfully utilized, with minimum area allocated to calculation. Big percentage of my building comprise of dwelling and as such the various principles of building planning some of them are below (Handy, 2002)

2.3 Selection of Site

The following factors should be kept in view while making the selection of site for building:

The site should be preferably being situated on an elevated and leveled ground. It should in flood-prone area.

The water table of ground at the site should not be high.

The site should be in developed area having facilities like shopping, educational institutions, recreation, hospitals, electricity, etc.

The soil at site should not be of black cotton soil and should have good value of bearing capacity.

Building services

Building services is the engineering of the internal environment and environmental impact of a building. In addition are the system installed in building to make them comfortable, functional, efficient and safe (Hall, 2009).

2.4. Building Codes and Standards

In the design and construction field, the codes and standards impact modern building construction and constant changing and it is difficult at the best to keep up with copious changes and how they impact building design. The aim of design is to achieve the acceptable probability that the structures being designed to perform a satisfactory durability during their intended life. The structure should be designed adequate, it means to transmit the design ultimate dead loads, wind loads and imposed loads safety from the highest supported level to the foundation (Arya, 2009)

. Bs 8110 Building Code: Part 1:1997

The British concrete institute standard, building code requirements for reinforced concrete, had permitted the design of a reinforced concrete structure in accordance of limit state principles using loads and resistance factors since 1963. A probability assessment of those factors' values and formats (Allen A., 2002)

2.2 Architectural Design

Architectural design of gymnasium deals with typically involves several key elements such as:

1. Layout and space planning: the layout must provide ample space for exercise equipment, workout areas, and sports if applicable.
2. Ceiling height: high ceiling s are essentially to accommodate activities are essential like basketball, volley ball. a typically gymnasium has a ceiling height of around 20 to 30 feet.
3. Flooring: the flooring should be durable, shock-absorbent, and easy to clean. Materials like rubber, hardwood or sports flooring commonly used.
4. Lighting: adequate lighting is crucial for safety and visibility. Large windows or skylights can provide natural light, but artificial lighting should also sufficient…

2.2.1 Architectural Design Overview

This is the first stage of project design and planning where architect decide the arrangement and layout of the building for meeting the project requirements and provide layout plan view, sections and elevations, perspectives etc. these drawings done by software such as ArchiCAD 23 and AutoCAD 2020

2.2.2 Basic Architectural Design Data

Architectural design data of Gymnasium should provide at least all of the following forms of architectural drawings. (, November, 2018)

1. Plan views

These presents the general setting out of the building drawn to the details of the building components arrangements such as beams, columns, walls and openings like windows and doors.

2. Section views

These drawings present the indoor of the building. Hidden information is revealed through section views. In these views the identification of the building height and the type of construction materials determined.

3. Elevations

Here the general view of the building is presented and they are drawn in fmy (4) forms depending on the building position in the plot, these include front and back elevation, right and left elevation.

4. Site plan

Here the whole project arrangement in the plot is implanted and presented clearly referring to the local regulations related to urban planning and development.

Not that the reference lines or grids should be thin to avoid confusion with other components of the drawing.

The architect should use the standard drawing formats that are easy for layout. The format should be ISO A series and margin distance should be 10mm and 5mm from edge for respective formats A0-A3. And A6. (Ernest, 1970)

2.3 Structural Engineering

Structural engineering is a sub-discipline of civil engineering in which structure engineers are trained to design a set of elements to form a structure. Structural engineers need to understand and calculate the stability, strength, rigidity of building structure. Structural engineering involves the analysis, design, construction and maintenance of structure that reinforce or counteract loads, such as Dams, bridges (Mrema, et al,, 2012)

2.3.1 Structural Plan

A structural plan is a long term (ten to fifteen years) satisfactory framework used to guide the development or redevelopment of land. It is used to define, future development and land use patterns; primary distribution network, infrastructure and main transportation routes; involves terminals; conservation and protected areas; and other key features for managing the direction of development. (Suzuki, et al, 2013)

2.3.2 Structural Design

Mechanical investigation of the stability, strength and rigidity of structures. the basic objectives in structures. The basic objectives in structural analysis and design is to produce a structure which is capable of resisting all applied load without failure during its intended life. The primary purpose of a structure is to transmit or support load. (Gionca & Mazzolani, 2003)

2.3.3 The Aims of Structural Design

Generally, the aims of structural design are to produce a structure capable of resisting all applied loads without failure during its intended lifespan, with appropriate degree of safety; sustainability of all the loads and deformations of normal construction and use. And finally, to have an adequate durability and resistance to the effect of heavy loads and fire. (BS8110-1, 1997)

Specific rules and regulations for playing basketball (International basketball federation) key rules related to the cmyt:

1. Cmyt dimensions: FIBA regulated basketball cmyts have specific dimensions including length of 28 meters (94FT) and width of 15 meters (50FT)

2. three-point line: FIBA uses three-point line located at a distance of 6.75 meters (22FT or 1.75 inches) from the basket.

3. Key (paint) area: the key also known as the paint have specific dimensions. The width of the key is 5.8 meters (19FT) at the top narrowing to 3.6 meters (11.8FT) at the baseline. The key also has free throw line which is 5.8 meters (19FT) from the backboard.

4. Basket height: the basketball hoops rim is set at a height of 3.05 meters (10FT) above the playing surface.

5. Cmyt markings: the cmyt features various marking including the center circle free throw line and boundary lines all of which must adhere to FIBA's specifications

2.3.4 Structural Design Procedures

Architectural design must by preliminary study and then start the sketch scheme by drawing the individual rooms of required areas as simple as rectangles drawn to scales and then after analyze the circulation and relationship of rooms between each other you can take it as critical part for others. (Andrew, 2014)

British standard of design (BS)

The British Standard has been established under direction of civil engineering, the building structure standards committee and sector board for building in Great Britain **(BS8110-1, 1997 AND BS8110-2&3, 1985).** The British Standard is commonly used standard used standard for structural design in Rwanda.

2.4 Design

Design is a plan for construction about implementation of an activity. In some case, the direct construction depends on engineering codes and graphic design) design usually has satisfy certain goals and constrains may take into account aesthetic, functional, economic, or some political considerations. Design includes architectural blueprints, engineering drawings and business process, circuit diagram. (Pahl, 2013)

2.4.1 Design Process

The design of structural planning and design requires not only imagination and conceptual thinking but also sound knowledge of practical aspects such as design codes backed by sample experience and judgments. The purpose of standards is to ensure and enhance the safety, keeping careful balance between economy and safety.

The design of any structure is categorized into the following two main type:

1. Functional design
2. Structural design

2.4.2 Function Design

The structure to be constructed should be primary serve the basic purposes for it is to be used. The building provides happy environment inside as well as outside. Therefore, the functional planning of building must take proper arrangement of rooms/halls to satisfy the need of client, good ventilation, lighting, acoustic etc. (Hubka, 2012)

2.5 Safe Design of Limit States

One criterion for a safe design is that structure should not become unfit for use, it should not reach a limit state during its design life. This is achieved, in particular, by designing the structure to ensure that it does not reach two important limit states.

2.5.1 Ultimate Limit State

This limit state is concerned with the safety of the people and the structure. This requires that whole structure or its elements should not collapse overturn or buckle when subjected to the design loads.

The design loads= 1.4DL+1.6LL

‘[The sections strength is determined using plastic analysis based on the short-term design stress-strain curve for concrete and reinforcing steel. (Radaj, 1990)

2.5.2 Serviceability Limit State

This limit state is concerned with comfort of the occupants: for example, the structure should not suffer from excessive vibration or have large cracks or deflection so as to alarm to user of the building. For reinforcement concrete structures, the normal practice is to design for the ultimate limit state, check for serviceability and take all necessary precaution to ensure durability. (Mosley, et al., 2012)

The main serviceability limit states are as follows:

a) Deflection

The deflection of the structure should not adversely, affect its efficiency or appearance.

Deflection of beams may be calculated, but may tend to be complicated because of cracking, creep and shrinkage effects.

b) Cracking

Cracking should be kept within reasonable limits by correct detailing. Crack widths may have calculated, but may tends to complicated and in normal cases cracking can be controlled by adhering to detailing rules regard to bar spacing in zones where the concrete is in tension.

c) Vibration

The structure should not under the action of wind loads of the people vibrate so much as to make people uncomfortable or in worst cases even to alarm people.

In analysis a section for serviceability limit states that assuming a linear elastic relationship for steel and concrete stresses. Allowance is made of stiffening effect of concrete in the tension zone and for creep and shrinkage. (Choo & MacGinley, 2002)

2.7 Building Construction Materials

Construction materials include manufactured products such as components cement, admixtures and steel. Naturally occurring materials such as stones and timber.

The following materials used in building construction:

2.7.1 Steel

This is the alloy of iron and carbon and sometimes other elements.

Because of its high tensile strength and low cost, it is a major component used in buildings, infrastructures, tools, ships, automobiles, machines and appliances.

Iron is the base metal of steel.

2.7.2 Concrete

Concrete is the mixtures of cement, aggregates (coarse aggregate and fine aggregate), water and admixtures. All the mentioned component of concrete are mixed together until produce a paste ready for use in construction works. (Kosmatkael.,, 2002)

Concrete can be used for all standard building both single storied and multi-stored and for suppression and retaining structure and bridge. (BANK, 2006)

2.7.2.1 Reinforced Concrete

Reinforced concrete is mixtures of coarse aggregates, fines aggregates, cement, and sufficient amount of water and with reinforcement bars. Therefore, reinforcing are designed to resist tensile stresses in particular regions of the concrete that may cause unacceptable cracking or structure failure. (Mathews & Rawlings, 1999)

The selection of the concrete type used depends on the required strength, loading intensity, size of structural members. The concrete strength of cylinders of concrete made from the desired mix ratio. Usually curved and tested after 28 days according to standard procedures

A class of 25/30 concrete has a characteristics cylinder crushing strength of 30 mm^2.

The table below shows the list of commonly used classes and also the lowest class appropriate for various types of construction.

Table 2. 1. Strength classes of concrete

Class	**Lowest class for use as specified**
C12/15	
C16/20	Plain concrete
C20/30	Reinforced concrete
C25/30	
C30/37	Pre-stressed concrete

2.7.3 Aggregates

Aggregates are important components of concrete materials such sand, gravel and crushed stones that are along with water and Portland cement which is essential concrete ingredients used in construction. Fine and coarse aggregates have some major differences. Smyces of main major differences between deep and shallow footings are: definitions, size of particles, smyces, function in concrete. etc. (Tahri, 2017)

2.7.4 Cement

Ordinary Portland cement is the most commonly used type of cement. The raw materials from which it is made are lime, silica, alumina and iron oxide. These constituents are crushed and blended in correct proportions and burnt in a rotary kiln. The clinker is cooked mixed with gypsum and the constituents are mixed with gypsum and ground to a fine powder to produce cement.

Cement acts as a binding material in concrete where by one bag of cement measured 50kg. (Kosmatkaet al.., 2002)

2.7.5 Water

Water used in concrete preparation must be clean and free from impurities that could affect the workability of concrete. a proportion of water will set up chemical reactions, which will harden the cement, the reminder is required to give mix the workability, and will evaporate some the mix while being cured, leaving voids. (Neville et al.., 1987)

Total weight of water in concrete

Weight of cement

For most mix ratio it varies between 0.4 and 0.7 concrete mix may expressed as 1:2:3

1 stand for cement, 2 stands for sand and 3 stands for gravels.

2.7.6 Admixture

An admixture is defined as a material that is added to the mix in small quantities to modify or enhance the properties of the concrete. Admixtures are used to achieve specific desired characteristics in concrete, like improved workability, strength and setting time. (BS8110-1, 1997) (Ganiron, 2013)

These are various types of concrete admixtures such as:

- Set-Accelerating admixtures
- Set-Retarding admixtures
- Water-Reducing admixtures and Air-Entraining admixtures

2.8 Building Components

2.8.1 Foundation

A Foundation is a structure constructed to transmit load of superstructure to the underlying soil. The word “foundation” is derived from the Latin word fund are. The dimension and the depth of foundation is determined by the structure and the size of building, its support and the nature and the bearing capacity of the ground. The choose of foundation is necessary to calculate the loads on the foundation and terminal the natural of subsoil bearing capacity. (Tomlinson, 2014)

2.8.1.1 Functional Requirement of The Foundation

The functional requirement of the foundation are follows:

Strength and stability: requirement from the building regulations as regards loading that the building shall be constructed with combined dead loads, imposed loads and wind loads that are sustained and transmitted to the ground without causing deflection or deformation of any part of building.

Foundation should be taken sufficiently deep to guard the building against damage or distress caused by shrinkage of soil. (Hillel, 1992)

2.8.1.2 Design of Building Foundations

The main purpose of providing a foundation for a building or another structure is to transfer its loads to the ground in safe manner. The dead loads of roofs, floors and the load bearing wall, and the imposed loads acting on these elements are transferred first to the foundations.

Several types of foundations are used for domestic, industrial, public and commercial buildings, the choice of particular type depends on factors like: form of the building construction, the building loads, type of subsoil … (Tomlinson, 2014)

2.9 Walls

A wall is a vertical structure typically made of materials like: bricks, concrete, steel, blocks or woods that separates or enclosures spaces, provide supports and can serves various purposes such as defining boundaries and offering privacy, or bearing loads in a building construction. Walls can be found in both interior and exterior settings and have been used for centuries in architecture and construction. The function of exterior wall is to provide shelter against wind, rain, ...

Wall also carries a load: provides a security or decorative and soundproofing (Jones, 1973)

2.9.1 Function Requirement of Wall

Particular functional requirement of wall are follows:

i. Stability and strength
ii. Thermal insulation
iii. Sound insulation
iv. Fire resistance
v. Load bearing capacity
vi. Aesthetic considerations
vii. Resistance to humidity

2.9.2 Types of Walls

The following types of walls are:

- Load bearing wall which may be includes load bearing external walls and load bearing internal walls
- Non load bearing wall which may be includes non-load bearing external wall and non-load bearing internal wall.

2.10 Floor

A Floor is a flat supporting element of the building which is constructed to provide level surface in order to support occupants of the building, furniture, equipment, and some partitions. The floor also is the bottom surfaces of the room on which one stands. Floors typically consist of sub floor for sustain loads and a floor covering used to give a good working surface. (Merritt, 2001)

2.11 Beam

Beam is horizontal platform of structure which supported by two or more columns which carrying lateral loads in a more general sense, they are structural members that external load tends to bend, the total effect of all the forces acting on the beam is to produce shear forces and bending moment within the beam. (Dhir, 1989)

2.11.1 Types of Beams

There are the following types of beams used in construction such as:

- Simply supported beam: there are supported at both ends but are free to rotate.
- Continuous beam: Extending more than two supports.
- Cantilever beam: supported only at one end.
- Overhanging beam: there are supported at one or both ends.
- Fixed beam: supported for both ends and fixed to resist rotation.

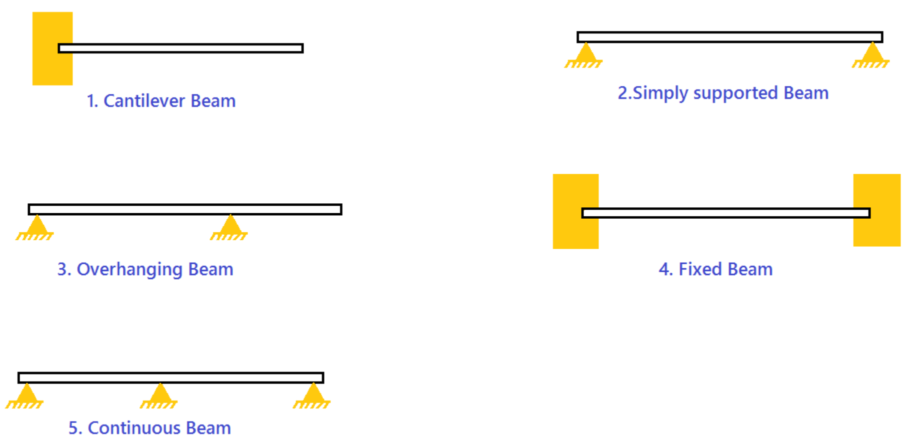


Figure 2. 1.types of beams

Classification beam based on cross-sectional shapes

1. Rectangular beam

This type of beam is widely used in the construction of reinforced concrete

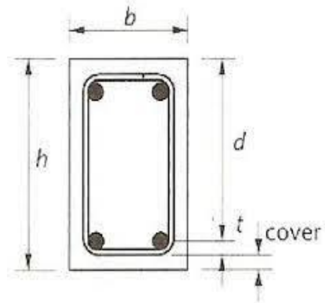


Figure 2. 2.rectangular beam sections

2. T-section beam

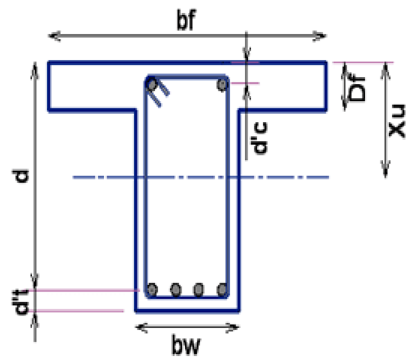


Figure 2. 3.T-section beam

2.12 Slab

Slab are flat horizontal elements which is constructed with concrete and reinforced concrete with various purposes including as floors, ceilings and roofs in buildings. They provide structural supports and create a flat surface for walking, working or placing objects. Slabs can be designed in different thicknesses in structural requirements of the construction project. slab may be simply supported or continuous over one or more supports and are classified according to the method of support as follows:

a) Spanning one way between beams or walls
b) Spanning two ways between supported beams or walls (Gamble, 2000)

2.13. Column

Column acts as vertical supports elements to the beam and slabs and transmits the loads to the foundations. Columns are primarily compression members, although they may have to resist bending moments transmitted by beams. Column may be classified as short or slender, braced or un braced depending on various dimensional and structural factors. (Dhir, 1989)

Failures modes of columns

Columns may fail in one of three mechanisms:

a) Compression failure of the concrete or steel reinforcement, this occur with columns are short
b) Buckling is probable with columns which are long or slender.
c) Combination of buckling and compression failure

2.14 Footing

Footing is a structural member used to supports columns and walls and transmits theirs loads to the ground. Reinforced concrete is a material suitable for footings and is used structure for both reinforced and structural. The permissible pressure on a soil beneath a footing is normally a few tons per square foot. The compressive stresses in the walls and columns of an ordinary structure may run as high as a few hundred tons per square foot. But it's also necessary to provide sufficient resistance to sliding and overturning. (Wilbur & Mead, 1933)

2.15 Stairs

A stair is a series of steps, each elevated a measured distance leading from one level of the structure to another. Stairs may be straight, round or may consist of two or more straight pieces connected at angles. Typically, stair composed many different terms like a stair way where by construction designed to bridge for vertical distance dividing it into smaller vertical distances, called steps.

Stair Case is an important component of a building providing access to different floors and roof of the building. It consists of a flight of steps and one or more intermediate landing slabs between the floor levels. (Chishom, Hugh, 1911)

2.16 Roof

A roof is the structure which forms the upper covering of the building, including all the materials and constructions necessary to support it on the walls of the building or on uprights; it provides the shelter against something as basic as bright sunshine, wind, snow, rain. (Cyril, 2000) Roof can also provide a pleasing appearance to the building. For the building which has volume capacity exceed 1000m^3 it is preferable to construct the roof to as single block made in materials capable of resisting the fire as roof to avoid the spread of the fire, the slab roof is made in concrete. (RHA, 2010)

2.16.1 Roof Types

The following types of roofs are:

i. Gable roof
ii. Flat roof
iii. Hipped roof
iv. Pitched roof

2.16.2 Functions of Roof

i. To prevent structure from dampness, heat, sound, etc...
ii. To carry loads from the roofs, live load and dead load.
iii. To provide protection from weather for workers working under any building.

I've learned a lot from the gymnasium projects that have helped us with my design, so we want my gymnasium to be done in line with the country's direction in helping Rwandans have a healthy lifestyle based on the quality of the sport we want to have more resmyces available to us than other projects done in other times and to have some games played there, so it makes it easier for fans to watch sports without being affected. We don't have a lot of rain or sunshine when we follow the games, we want to have enough places to accommodate a lot of fans and some of the best games we can play for my teams, such as volleyball and basketball and a lot of great games that can be enjoyed in my country and have qualified players who have done enough training and have more talented players to win more trophies.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research project procedures and techniques used during the study, the sample elements description, the analysis methods, data collection techniques, and some calculations techniques that were used by the researcher during data processing and analysis. According to (Loubet, 2000)**,** a method is a set of intellectual operations which enables to analyze, to understand and to explain the analyzed reality, in this research each step has its own method and techniques. In briefly this chapter mentioned all necessary details for the architecture and structure elements to be analyzed in the next chapter depends on engineering books regarding the principles of designing.

3.1.1 Collection of Data

Types of data

- **Primary data**
- **Secondary data**

In this project different data shall be collected and used after proper analysis. These include but not limited to the following

Primary data

These shall be obtained directly from the architectural drawing. They shall be done by measuring from different dimensions member and structural members. These measurements will be in terms of length, width, thickness from this direct measurement, other data shall be delivered. These shall include calculation of area and volume (Boslaugh, 2007)

Secondary data

Secondary data refers to data which collected by someone other than the user common smyces of the secondary data for social sciences include censuses, information collected government department, organizational records and data that was original called for other research purpose. It can save time that would otherwise be spent collecting data (Boslaugh, 2007)

3.1.2 Researcher Methods

To achieve to the attainment objectives of this research project. Different were used which are shown on the following:

a) To be in close with the supervisor as important method used

b) Site observation

c) Carrying out architectural drawing of G+1 GYMNASIUM

d) To give the required dimensions of the building component

e) To design structural element by using British standard 8110 and Euro code 2

Materials Used

a) Microsoft office, excel

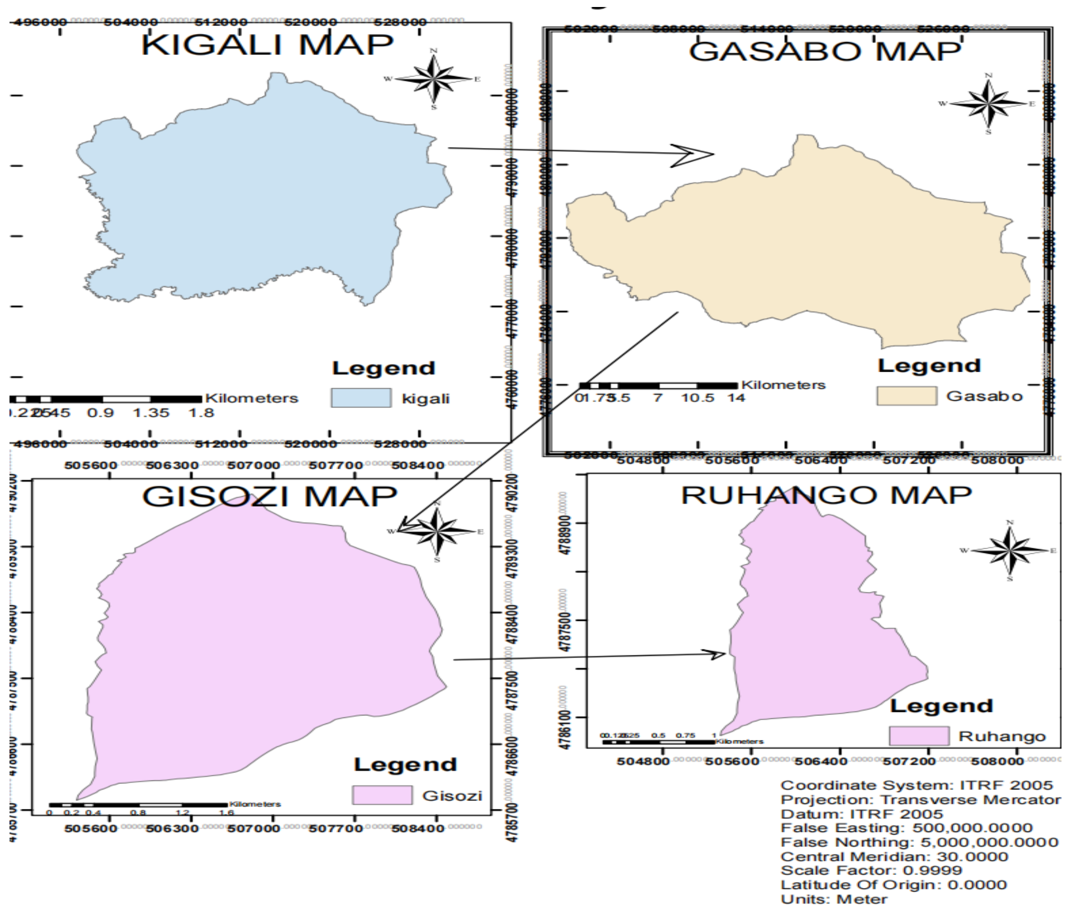
b) Arch cad

c) Prokon

d) Book and Lecturer note

3.1.3 Location of the Site and Description of The Study Area

The site of this project is rectangular and is located in Kigali city, Gasabo district, Gisozi sector



.

Figure 3.1: location of the site and description of area

3.5 Planning Considerations

Design:

To design a structure with less anomalies and errors, it is very necessary to choose a suitable design method. Structure is embedded with no of elements and components hence error in design can lead failure of the entire structure. There are two design method available as given below:

a) Working stress method
b) Limit state design method

Working stress method

a) This method is based on condition that the stresses caused by service loads without load factors are not to exceed the allowable stresses which are taken as fraction of the ultimate stresses of the materials, fc for concrete and fy" for steel
b) Limit state is a method in which structure or structural components ceases to fulfil the function for which it is designed. Below the structural element are designed based on limit state method which consider the variability's not only in resistance but also in the effect of different combination in the two-limit state method. In this method all appropriate state must be considered in design to ensure a degree of safety. By adapting this method, the structural leads to better and accurate results (Wagh et al, 2006)

3.6 Structural Design

The structural was done to provide safe and economical structural members able to carry the loads. The structural elements are: slabs, beams, columns, stair, and foundation During the design of structural elements slab, beam, column, stair and foundation the manual calculation method have been used with British standard and prokon software has been used for determining the bending moment and shear orces quantities and diagrams for design structural element beams the prokon software has been used for all details (Brooker, 2006)

3.6.1.Design of slab

1.Dead load

Self-weight= safety factor × meter× meter× thickness of slab× unit weight

Finishes = safety factor ×meter ×meter ×thickness of finishes

Total dead load= self-weight – finishes

2.Live load

Live load: safety factor ×meter ×meter ×live load of material

$\lambda = \frac{ly}{lx}$,where λ is ratio of long side and short side, Ly is long side, lx is short side

3.Bending moment on the slab

Mx=βsx*n*lx^2

My=βsy*n*lx^2

Where **Mx** is the moment at long side and **My** is the moment at short side

βsx and βsy are coefficient related to the design of slabs

n is total loads on the slab and lx is short side of the slab.

Required area of steel reinforcement on slab

As=$\frac{M}{0.95fyz}$ where M is the maximum design moment, fy is the characteristic strength of steel

3.6.2.Beam design

Computation of the beam: $\frac{lmax}{15} \leq h \leq \frac{lmax}{8}$ where lmax is the largest span between two consecutive beams.

Computation of web of flange of the beam (bw)

The breath of beam should be: 0.5 ≤ bw≤1

Where **bw** is the web of flange of the beam, h is the height of beam

Computation for T beam of the flange (bf)

Bf =≤ {12hf+bw, ½ lmax, 1/3 lmax} where bf is the width of flange of beam, **hf** is the thickness of the slab, **D** is the distance between beams and **bw** is the web of flange of beam**.**

- **Loads on the beam**

Masonry loads= safety factor x meter x thickness of wall x height of wall x unit weight

Plaster =safety factor x thickness of finishes x height of wall that can paint x meter x in and out x unit weight

Factored own weight of the beam = safety factor x none factored own weight of the beam

- **Load on column**

Calculation of dead load on column Cross section: length × width

Load from the slab = total dead load of slab× influence area from the slab

Self-load of the column = safety factor × area of column × height of column× unite weight

Load from the beam = safety factor ×width of the beam× height of the beam× (length

+width of influence area) × unit weight

Masonry walls = safety factor thickness of slab× height of slab× (length +width of influence area) × unit weight

Plaster on the wall = safety× thickness of finishes× height of finishes× (length +width of influence area) × unit weight.

- **Live load**

Live load=live load of slab× influence area from the slab

Load applied on the floor of the column

Self-load of the underground column =safety factor × area of column × height of underground column × unit weight

Total Loads = [(load from the slab +load from the beam + masonry load + plaster on the wall live load from the slab) × number of the story] + [(self-weight of column × number of floor) + self-load of underground column) + (load from the slab + load from the beam + live load from the slab)]

Steel reinforcements for the column

Slenderness ratio λ=$\frac{lo}{a}$ or λ= 0.7H With $\frac{lo}{a} = 0.7$ for interior column and 0.9 for exterior column where λ is slenderness ratio, h is effective height of column and a is width of column.

$\frac{100\ AS}{bh}$= value from design chart

3.6.3. Foundation design

Total characteristics live loads=$\frac{total\ live\ load}{safety\ factor\ of\ live\ load}$

Total characteristics permanent loads= $\frac{total\ design\ permanent\ load}{safety\ factor\ of\ dead\ load}$

Total characteristic load = total characteristic live load + total characteristic permanentload

Estimation foundation weight soil =10 % of total characteristic load

Total load on the soil = total characteristic load + estimate foundation weight soil.

- **The required area of foundation**

Af=$\frac{total\ load\ on\ the\ soil}{design\ bearing\ capacity}$

Af= $\frac{Gk+Qk+w}{Pb}$

WhereA_f: area of foundation

Pb is the bearing capacity of the soil

Design pressure P=$\frac{Nc}{Af}$, Where P: pressure design, $N_{c:}$ design load on column

- **Checking of shear force**

The shear force Q ≤0.54Rbt*Ab

Where Q: shear force; R_{bt}: concrete design tensile strength Ab: average lateral area of punching pyramid

Ab=af*h_o

Where h_o**:** effective height of footing; af: width of foundationQ= P× bf (lc-ho)

Where P: design pressure, bf: length of foundation,

lc: distance from the effective heightto the end of foundation, h_o: effective heigh.

- **Moment calculation**

Bending moment in y-y direction Myy=P*($\frac{af-ac}{2}$)*af*($\frac{af-ac}{4}$)

Where p is the design pressure

af is side of foundation

ac is side of the column

As of steel is calculated as the same as the area of rectangular beam

3.6.4.Stairs design

The condition of slope relationship550<2R+G<700, where T is tread and R is riser.

Angle of pitch tan ∝= $\frac{opposite}{adjacent}$

The minimum pitch of the stair is 25^0 degree and maximum pitch is 45^0 degrees.

The thickness of waist d=$\frac{lx}{26}$ where d is effective depth and lx is the horizontal distance of stair.

The dead load includes own weight of the step, own weight of the waist slab, and surface finishes on the steps and on the soffit.

Design dead load=1.4*thickness of waist*width of landing*length of landing*unit weight of concrete.

Live load is taken as building design live load plus 1.5KN/m^2 with a maximum value of 4KN/$m^{2.}$

Design live load=1.6*imposed loads from table 1 of the code (bs6399-1-1996) *width of landing*length of landing.

Bending moment of stairs=$\frac{wl}{10}$

Area of steel required=$\frac{Mmax}{\eta.fcu.bd^2}$

Where $\boldsymbol{\eta}$: coefficient related to design of members subjected to bending moment,

fcu:design compression strength, b: the width of the compressive area, d: effective depth

3.7. Load on the ramp

Dead loads = safety factor × effective height× meter× meter× unite weight Load from finishes = safety factor× thickness of finishes

Live load = safety factor × live load of material

- **Calculation of steel reinforcement in the ramp**

Am=$\frac{M}{\eta.fcu.b.d^2}$Where αm: coefficients related to the design of members subjected to bending moment Rb: design concrete compression strength, b is the width of the compressive area and d:

effective height (m) can be positive or negative if m is positive = is the moment at the bottom if m is negative the moment is at top.

- **Ground beam design**

Effective height of the beam=$\frac{lmax}{15}$≤h$\frac{lmax}{10}$

Steel reinforcement As=$\frac{Cross\ sectional\ area\ x\ o.5}{100}$Design of ramp Dl=h*($\frac{1}{20}\ and\ \frac{1}{30}$) where h is height of column, dl is waist

CHAPTER 4. RESULTS AND DISCUSSIONS

4.0. Introduction

This building has 7 rooms, 3turning stairs, 1 Ramp-up for physical disabled people and it has 1 Playing place and seating area that will receive 1300 people

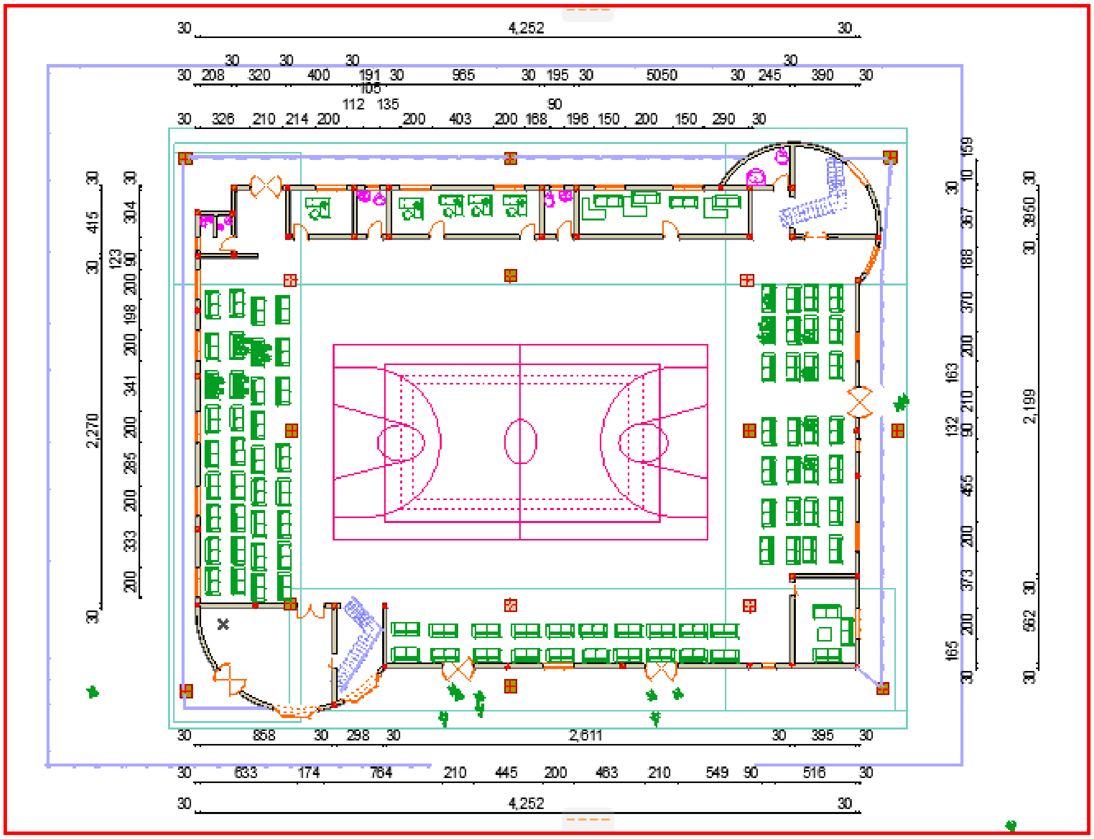


Figure 4. 1: Floor Plan

4.1. Design of slab

Slabs are plate elements forming floors and roofs in buildings which normally carry uniformly distributed loods. Slab may be simply supported or continuous over one or more supports and are classified according to the method of support as follow:

Spaning one way between beam or walls

Spanning two ways between the support beams or walls

Slab is designed by considering critical panel from figure of structural plan.

- **Critical Panel**

Slab is designed by considering critical panel of structural plan.

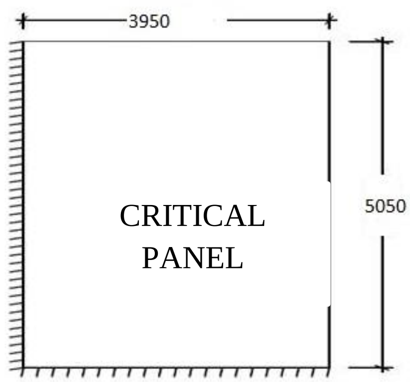


Figure 4. 2:Two adjacent edge discontinuous critical panel.

- **Pre-design**

Live load=3KN/m^2 from table 1 of BS 6399-1 1996

Main bars are 10mm of diameter.

Cover: -mild: 25mm

-Exposure condition 2h: 25mm

Let's take 25mm

Unit weight of RC =25 KN/m^3

Floor finishes = 1.8KN/m^3

Exposure condition, 1 hmy

Fcu=30N/mm^2

f_y =460 N/mm^2

b:1m=1000mm

$\frac{lx}{d} = 26$, $d = \frac{\text{lx}}{2.6} = \frac{3.95}{26} = 151\text{mm} \approx 150\text{mm}$

Lx/20 <L>lx/40

197.5<L> 98.75 mm

Slab thickness =150mm

Effective depth of the slab = h-cover -$\frac{\theta}{2}$ = 150-5-25=120mm

b: 1m=1000mm

$\frac{ly}{lx} = \frac{5.05}{3.95} = 1.28 < 2$. This is 2 ways slab

N = 1.4Gk + 1.6Qk

Dead load:

From slab = 0.2*25 = 5 KN/m^2

From finishes = 1.8KN/m^2

Total dead load =5 KN/m^2 + 1.8 KN/m^2 = 6.8KN/m^2

Imposed load:

Minimum imposed load from the slab of apartment is 3KN/m^2

Total design load = 1.4*Gk + 1.6*Qk, Where Qk is the imposed load from table 1 of BS 6399-1 1996

Total design load = 1.4*6.8 KN/m^2 + 3*1.6 KN/m^2= 14.32 KN/m^2

- **Design for Shear and bending moment**

- **Design for moment**

Short span discontinuous edge

Mid span = Msx = β_{sx}*Wl_x^2

Support = Msy = β_{sy}*Wl_y^2

M^+=0.081*14.32*3.95^2 = 18.097KNm

Long span discontinuous edge

M^+=0.056*14.32*5.05^2= 20.45KNm

- **Design for shear**

Vsx= $B_{vx}nl_x$

Vsy =$B_{vy}nl_y$

Short span

Discontinuous edge: V_{sx}=0.41*14.32*3.95= 23.19KN

Long span

Discontinuous edge: V_{sy}=0.33*14.32*5.05= 23.86KN

Then we take maximum values for design which are:

Moment: 20.45 KNm

Shear: 23.86 KN

Analysis for Sagging moment

Moment = M = 20.45 KNm

M_{RC} =0.156 $fcubd^2$ = 0.156*30*1000*120^2 = 67.39 KNm

M_{RC} > M hence reinforcement in compression is not required.

$K = \frac{M}{fcubd^2} = \frac{20.45*10^6}{30*1000*120^2} = 0.047 < 0.156\ ok$

Z=120[0.5+ (0.25 -0.047 /0.9)$^{1/2}$] ≤0.95d

Z=101.18<114 ok

As=$\frac{M}{0.87fyz}$

As=$\frac{20.45*10^6}{0.87*460*101.18}$= 505.035 mm^2,

Asprov. = 565mm^2 provide 5T12@ 200 c/c

Asmin =$\frac{100}{Ac} = 0.13$

Asmin =$\frac{1000*150*0.13}{100} = 195$ mm^{2,}

As min prov =235mm^2 provide 3T10@ 250 c/c

As max=$\frac{4*1000*150}{100} = 6000$ mm^2

Analysis for shear reinforcement

Maximum shear =23.86 KN

W =$\frac{v}{bd}$ V=$\frac{23.86*10^3}{1000*120} = 0.19\text{N/mm}^2$

$$W_c = \frac{0.79\left[\left(\frac{(100As)^{\frac{1}{3}}}{bd}\right)*\left(\frac{(400)^{\frac{1}{4}}}{d}\right)*\left(\frac{(fcu)^{\frac{1}{3}}}{25}\right)\right]}{1.25}$$

$\left(\frac{100\times448}{1000\times120}\right)^{\frac{1}{3}} = 0.72 < 3$ ok

$(\frac{400}{120})^{1/4} = 1.23 > 1$ ok

$(\frac{30}{25})^{1/3} = 1.1$

$W_c = \frac{0.79*0.72*1.23*1.1}{1.25} = 0.61\text{N/mm}^2$

W<Wc

Hence the shear reinforcements are not required.

Deflection check

Basic span/d=26

Modification factor

M.F=$\frac{477-fs}{120(\frac{M}{bd}+0.9)} \leq 2$

$\mathbf{fs=\frac{2}{3}fy\frac{As}{Asprov} * \frac{1}{\beta} =}$ $\mathbf{fs= \frac{2}{3}460\frac{505.039}{565} = 274.11}$

$\frac{M}{bd^2} = \frac{20.45*10^6}{1000*120^2} = 1.42$

$M_f = \frac{477-274.11}{120(0.9+1.42)}$ =0.72≤ 2 OK.

Allowable span/d=26*M_F = 26*0.72= 18.72

Actual span=Span/d=$\mathbf{\frac{2150}{120} = 17.9}$ OK

Allowable span is greater than Actual span

Hence the slab is safe from deflection.

Cracks Control

BS8110 states that the maximum spacing of bars in tension is given by 3d = 3x120mm = 360 mm.

Since all the spacing is less than 360mm, there is no cracking.

4.2. Design of beam

Pre-design

Width of the beam b_w = 200 mm

The value of **h** is found after verification of the following condition:

$\frac{Lmax}{12} \leq h \leq \frac{Lmax}{8}$

Lmax = 5050 m;

5050/12 = 420 mm;   5050/8= 631.25mm

Let take h = 550mm

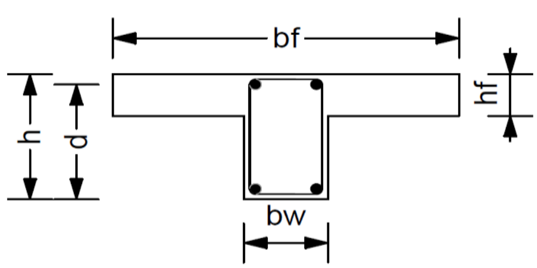


Figure 4. 3:Flanged T-beam for beam D-D without dimensions

$$bf = bw + \frac{lz}{5} = 200 + \frac{5050 * 0.7}{5} = 907mm$$

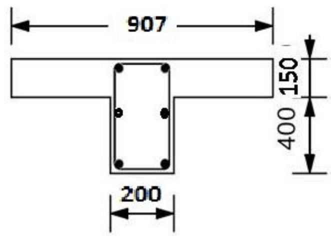


Figure 4. 4:Flanged T-beam for beam D-D with dimensions

fcu=30N/mm^2

fy = 460 N/mm^2

Height of the beam = 550mm

Cover:-mild: 25mm

-Exposure condition 2h: 25mm

Let's take 25mm

Effective depth: -main bar = T16

-Link =T8

d=550-8-8-25=509 mm

Design for shear and bending moment

- **Dead loads calculation**

Dead load from masonry=0.2*2.85*20=11.4KN/m

Dead load from finishes=0.03*2.85*22*2=3.762KN/m

Dead load from plinth=0.03*0.15*22*2=0.198 KN/m

Design load from slab = 0.2*25 KN/m^3+1.8 KN/m^2 = 6.8 KN/m^2

$P_1 = \frac{wlx}{3}(\frac{3-m^2}{2})$ m=$\frac{lx}{ly}$ m=$\frac{3.95}{5.05} = 0.78$

Where w is design load from slab

$P_1 = \frac{6.8*3.95}{3}\left(\frac{3-0.78^2}{2}\right) = 10.70KN/m$

- **Imposed loads calculation**

$P_1 = \frac{wlx}{3}(\frac{3-m^2}{2})$ $m = \frac{lx}{ly}$ $m = \frac{3.95}{5.05} = 0.78$

$P_1 = \frac{3*3.95}{3}\left(\frac{3-0.78^2}{2}\right) = 4.72KN/m$

Total dead load from slab = 11.4 KN/m + 3.762 KN/m + 0.198 KN/m 10.70 KN/m =26.06 KN/m

Total imposed load from slab = 4.72 KN/m

Total design load on beam = 1.4*26.06KN/m+1.6*4.72 KN/m=44.036KN/m

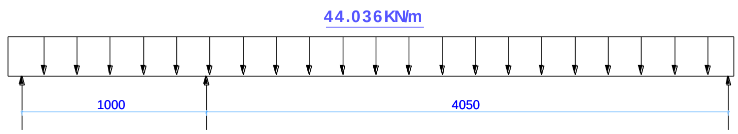


Figure 4. 5:Loading diagram (KNm) of beam D-D

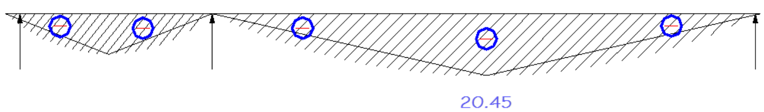


Figure 4. 6:Bending moment diagram (KNm) of beam D-D

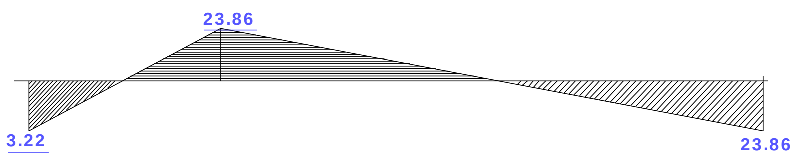


Figure 4. 7:Shear force diagram (KN) of beam D-D

- **Design for sagging moment**

Sagging Moment=126.55KNm

$M_{RC} = 0.45fcubhf(d - \frac{hf}{2})$

$M_{RC} = 0.45 * 30 * 907 * 200\left(509 - \frac{200}{2}\right) = 1001.6KNm$

M_{RC}>M, the neutral axis is in flange, so the beam will be designed as a rectangular beam

$M_{RC} = 0.156 * 30 * 1000 * 509^2 = 1212.49$KNm so $M < M_{RC}$

$K = \frac{M}{fcubd^2} = \frac{126.55*10^6}{30*1000*509^2} = 0.016 < 0.156$, no compression bars are required

Z= d [0.5+ (0.25- k /0.9)$^{1/2}$] ≥ 0.95d

Z= 509 [0.5+ (0.25- 0.016 /0.9)$^{1/2}$] = 499.78 > 483.55

Let's take Z = 483.55mm

As= $\frac{M}{0.87fyz} = \frac{126.55*10^6}{0.87*460*483.55} = 653.95mm^2$

As min=$\frac{0.3*1000*550}{100} = 1650\text{mm}^2$

As max=$\frac{4*1000*550}{100} = 22000\text{mm}^2$ ok

As provided = 1884 mm^2 provide 6T20

- **Deflection check**

Span/6=26

Modification factor (M.F)

M.F= $0.55 + \frac{477-fs}{120(\frac{M}{bd^2}+0.9)} \leq 2$

fs=$\frac{2}{3}$fy $\frac{\text{Asrequired}}{\text{Asprovided}} * \frac{1}{\beta}$ fs=$\frac{2}{3}460\frac{1650}{1884}$ *1=268.5

$\frac{M}{bd^2} = \frac{126.55*106}{200*509^2} = 2.44$

M.F= $0.55 + \frac{477-268.5}{120(2.44+0.9)}$ =0.52<2 ok.

Allowable span/d=26*M.F =26*0.52=13.52

Actual span/d=5050/509 = 9.92<13.52

Allowable span/d is greater than Actual span/d

Hence there is no deflection.

Shear design

V=ql/2=44.036*5.05/2=111.19 KN

$w = \frac{v}{bd} = \frac{111.19*10^3}{1000*509} = 0.2$ N/mm^2

$$W_c = \frac{0.79\left[\left(\frac{(100Asp)^{\frac{1}{3}}}{bd}\right)*\left(\frac{(400)^{\frac{1}{4}}}{d}\right)*\left(\frac{(fcu)^{\frac{1}{3}}}{25}\right)\right]}{1.25}$$

$$\left(\frac{100\times2500}{1000\times2945}\right)^{\frac{1}{3}} = 0.43 < 3 \text{ ok}$$

$$\left(\frac{400}{509}\right)^{1/4} = 0.94 < 1 \text{ take } 1$$

$$\left(\frac{30}{25}\right)^{1/3} = 1.1$$

$$W_c = \frac{0.79*0.43*1*1.1}{1.25} = 0.29 N/mm^2$$

W<Wc

Therefore shear reinforcement bar are not required

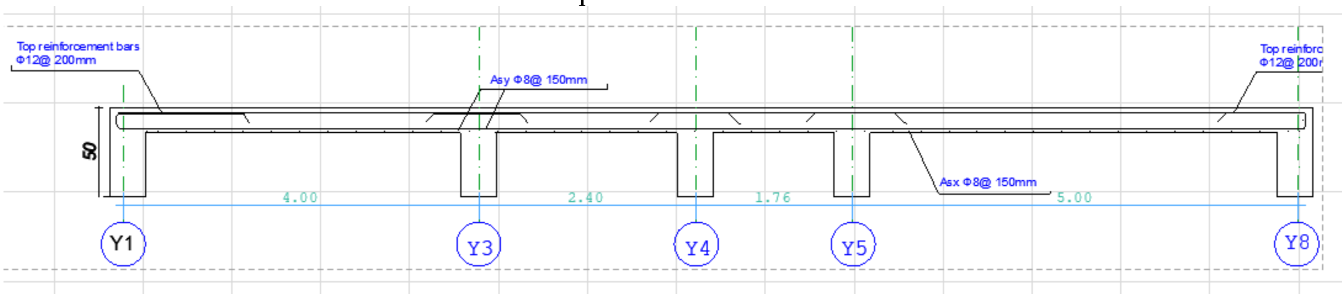


Figure 4. 8:Reinforcement layout in beam

4.3. Design of a column

The column is designed by considering the load taken down on the heavy loaded column by using influence area method. The loads taken down are shown on appendix 10

- **Specifications**

-Height= 2.850m

-Section=200mm*200mm

-f_{cu}=$30N/mm^2$

-f_y= $460/mm^2$

-Thickness of finishing= 30mm

-Imposed load=3KN/m^2

-Unit weight of finishing=$22KN/m^2$

-Unit weight of masonry=20 KN/m^3

- **Check for slenderness of column**

The effective height of the column is given by:

le=βlo where:

le: effective height

β=coefficient used to determine effective height of the column

0.75< β<1

lo: clear height

β= (0.75+1)/2=0.85

$le = 0.85 * 2.85 = 2.42m$

$\frac{le}{h} = \frac{2.42}{0.2} = 12.1$

$\frac{le}{b} = \frac{2.42}{0.2} = 12.1$

Since the ratios above are less than 15, we have the short unbraced column. Therefore the column will be designed as short unbraced column.

Finding moment (M), shear force and Reactions

Reaction from beam 19-19= 516.52KN

Reaction from beam D-D= 279.24KN

$h' = d = h - \text{cover} - \frac{\Phi\text{main bars}}{2}$

$h' = 200 - 25 - 8 - \frac{16}{2} = 159\text{mm}$

$b' = 200 - 25 - 8 - \frac{16}{2} = 159\text{mm}$

Column moments calculation in y-direction

$K_{AB} = \frac{1}{2} * \frac{bh^3}{12L_{AB}} = \frac{1}{2} * \frac{0.2*0.55^3}{12*5.05} = 5.49*10^{-4}$

$K_{CD} = \frac{0.2^4}{12*2.85} = 4.67 * 10^{-5}$

$\varepsilon K = K_{AB} + K_{col} = 5.49 * 10^{-4} + 4.67 * 10^{-5} = 5.95*10^{-4}$

Distribution factor for the column= $\frac{K_{col}}{\epsilon K} = \frac{4.67*10^{-5}}{5.95*10-4} = 0.078$

- **Fixed end moment at B**

F.E.$M_{BA} = \frac{qL^2}{12} = \frac{\mathbf{936.8941}*5.05^2}{12} = 1991.094\text{KNm}$

Difference of moments=1991.094KNm

Column design moment= 1991.094KNm * 0.078= 155.305 KNm

- **Column moments in X-direction**

Stiffness calculation:

$K_{AB} = \frac{1}{2} \times \frac{b.h^3}{12 \times L_{AB}} = \frac{1}{2} \times \frac{0.2 \times 0.55^3}{12 \times 4.05} = 3.42 \times 10^{-4}$

$K_{BC} = \frac{1}{2} \times \frac{b.h^3}{12 \times L_{BC}} = \frac{1}{2} \times \frac{0.2 \times 0.55^3}{12 \times 2.25} = 6.16 \times 10^{-4}$

$K_{Col} = \frac{0.2^4}{12 \times 2.85} = 4.67 * 10^{-5}$

$\varepsilon K = 3.42 \times 10^{-4} + 6.16 \times 10^{-4} + 4.67 * 10^{-5}$ =0.0010047

Distribution factor = $\frac{K_{Col}}{\varepsilon K} = \frac{4.67 * 10^{-5}}{0.0010047} = 0.046$

Fixed end moment at B:

F.E.$M_{AB} = \frac{q.L^2}{12} = \frac{\mathbf{936.8941} \times 4.05^2}{12} = 1280.6171 KNm$

F.E.$M_{BC} = \frac{q.L^2}{12} = \frac{621.8615 \times 2.25^2}{12} = 262.3478 KNm$

Difference of moments = $1280.6171 KNm - 262.3478 KNm = 1018.2692 KNm$

Column design moment =$1018.2692 KNm \times 0.046 = 46.84 KNm$

My=155.305 KNm

Mx=46.84 KNm

$h' = h - cover - \frac{16}{2} - \emptyset link = 319 mm$

$h' = 200 - 25 - 8 - \frac{16}{2} = 159 mm$

$b' = 200 - 25 - 8 - \frac{16}{2} = 159 mm$

if

$\frac{My}{b'} > \frac{Mx}{h'}$

$\frac{155.305}{0.159} > \frac{46.84}{0.159}$

Then the increased single axis design moment is:

$M'y = My + \beta . \frac{b'}{h'} \times Mx$

β is specified in table 3.22 BS 8110 by considering $\frac{N}{b.h.fcu}$:

$\frac{N}{b.h.fcu} = \frac{\mathbf{936.8941} \times 10^3}{200 \times 200 \times 30} = 0.78$

$\beta = 0.3$

$M'y = 155.305 + 0.3 \frac{159}{159} \times 46.84 = 169.357$ KNm

$\frac{N}{b.h} = \frac{936.8941 \times 10^3}{200 \times 200} = 23.42N/mm^2$

$\frac{M}{b.h^2} = \frac{169.357 \times 10^6}{200 \times 200^2} = 21.169$

$\frac{d}{h} = \frac{159}{200} = 0.8$

$\frac{100.Asc}{b.h} = 5.6$

$Asc = \frac{1.2 \times b \times h}{100} = \frac{5.6 \times 200 \times 200}{100} = 2240mm^2$

$Ascmin = 0.004. b. h = 0.004 \times 200 \times 200 = 160mm^2$

$Ascmax = 0.06. b. h = 0.06 \times 200 \times 200 = 2400mm^2$

$Ascmin < Asc < Ascmax$

$160mm^2 < 2240mm^2 < 2400mm^2$ The area is satisfactory

$Asprov = 2454mm^2$ Provide 5T25@120 c/c

- **Shear reinforcement**

BS 8110 states that the diameter of ring $\emptyset\, ring$ is equal to ¼ of the bigger longitudinal bar and this must be greater or equal to 6mm

$\emptyset\, ring = \frac{1}{4} * 25 = 6.25\, mm$, take $\emptyset\, ring = 8mm$

The maximum spacing S is equal to 12times the diameter of the smaller longitudinal bar

$S = 12 * \emptyset = 12 * 25mm = 300mm$,we take S = 300mm

Reinforcement in column:

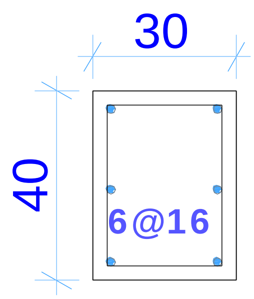


Figure 4. 9:Reinforcement layout for column

3 types of columns were considered as it is shown on the structure details:

- Columns of 300 mm of diameter at the main entrance for decoration purpose;
- Columns of 400 mm x 300 mm on the overloaded areas;
- Columns of 200 mm x 200 mm where the columns are closed one another and for the economical purpose.

4.4. Design of stair

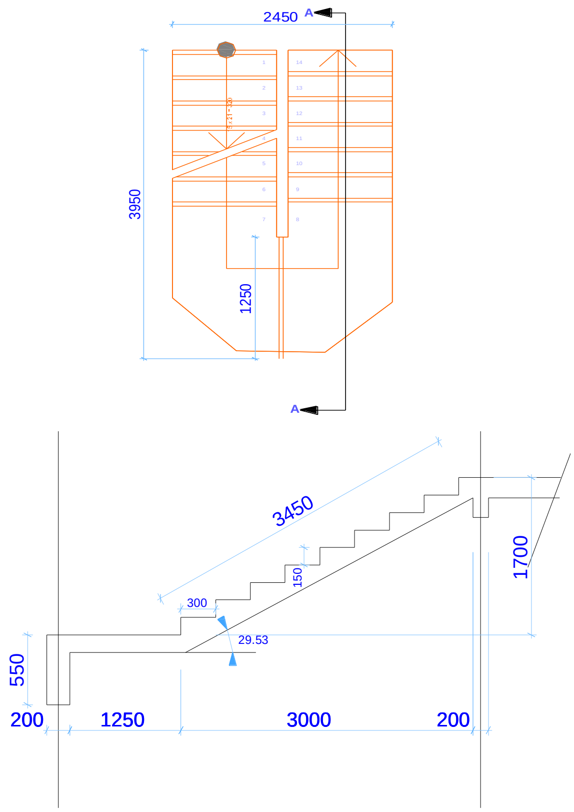


Figure 4. 10:Plan view and section of public stair to be designed and its section

Specification

fcu = 30N/mm^2

fy = 460 N/mm^2

∅Main bars: 10mm

Cover = 25mm

Unit weight of concrete = 25N/m^3

Imposed load=1.5KN/ mm^2

Finishers unit weight=22KN/ m^3

Riser $= 150mm$

Going (tread)$= 300mm$

Pitch $\leq 38°$

Number of steps in flight≤ 18

$700mm > G + 2R > 550mm$

$700mm > 300mm + 2 * 150mm > 550mm$ ok

Number of risers = Number of goings +1=9+1=10 risers

The stair landing slab has 15mm of plaster finish underside and at the top

Effective span = $la + 0.5(l_{b1} + l_{b2})$ =4.15+0.5(0.2+0.2)=4.35m

Depth of waist = $\frac{4350mm}{26} = 167mm$

Height of waist is equal to the thickness of slab take height=150mm

Stair slop= $\tan^{-1}\frac{1.7}{3} = 29.53^{o}$

Horizontal distance=4150mm-1250mm+200mm/2=3000mm=3m

Slope distance = $\sqrt{(1.7)^2 + (3)^2} = 3.45m$

- **Load calculation**

Load from landing

The thickness of slab including the top and bottom side finish equal to 150 mm

Dead load = $0.15 \times 25 \times 1.4 = 5.25KN/m^2$

Imposed load = $1.5 \times 1.6 = 2.4KN/m^2$

Total load=5.25 KN/m^2+2.4 KN/m^2=7.65KN/m^2

Applied load from landing slab =7.65$KN/m^2 * 0.5(1.250)1.200m^2 = 5.7375KN$

One half of the load on the landing slab is included for the stair slab under consideration. The loaded width is 1900mm

Stair slab loading

The average thickness including finishes is: $150 + \frac{148}{2} = 224mm$

Dead load $= 0.224 \times 25 \times 3.45 \times 1.4 \times 1.9 = 51.39KN$

Imposed load $= 1.5 \times 3 \times 1.9 \times 1.6 = 13.68KN$

Total load= $51.39KN + 13.68KN = 65.07KN$

The dead load while imposed load acts on the span length is calculated by using the slope length

The total load on span length=5.7375 KN+65.07KN=70.8075KN

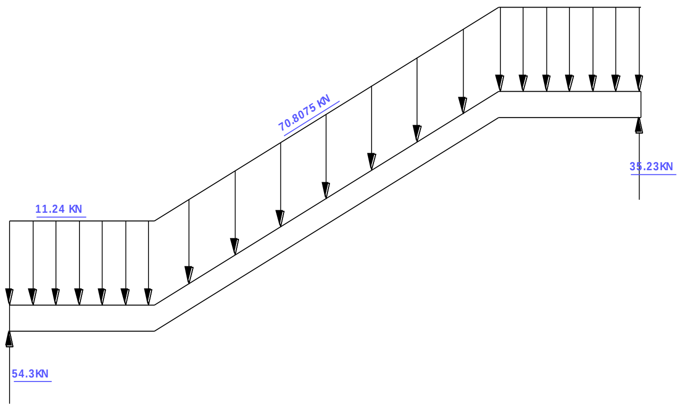


Figure 4. 11:Loading of stair- slab and its bending moment diagram and shear force diagram

Design for moment and shear

a. Design for moment

Support and mid span=$\frac{WL}{10} = \frac{70.8075KN*4.35m}{10} = 30.80KNm$

Design shear

RA+RB=70.8075KN

$\varepsilon MA = 4.35RB - 5.7375 \times 0.725 - 65.07 \times 3.35$=0

= $4.35RB - 222.144$=0

$R_B = \frac{222.144}{4.35} = 51.06KN$

$R_A = 70.8075KN - 51.06KN = 19.73KN$

Maximum shear force equal to 51.06 KN

Moment reinforcement

Effective depth d is $150 - \frac{10}{2} - 25 = 120mm$

$b = 1200mm$ is the width of the stair

$\frac{M}{b.d^2} = \frac{30.8\times10^6}{1200\times120^2}$ =1.78

$\frac{100\times As}{b.d} = 0.4$

$0.24bd = 100.As$

$As = \frac{0.4\times1200\times120}{100} = 576mm^2$

$As\ prov = 628mm^2$ for 8T10@120 C/C

The minimum area of reinforcement:

Asmin=$\frac{0.13*150*1000}{100} = 195mm^2$

Shear reinforcement design:

Maximum shear = 51.06 KN

w $= \frac{v}{b.d} = \frac{51.06\times10^3}{1200\times120} = 0.35N/mm^2$

w$c = \frac{0.79(\frac{100\times628}{b.d})^{1/3}(\frac{400}{d})^{1/4}(\frac{fcu}{25})^{1/3}}{1.25}$

$\left(\frac{100\times628}{1200\times120}\right)^{\frac{1}{3}} = 0.75 < 3$

$(\frac{400}{120})^{1/4} = 1.35$

$(\frac{30}{25})^{1/3} = 1.1$

w$c = \frac{0.79\times0.75\times1.35\times1.1}{1.25} = 0.7N/mm^2$

$wc > w$

$0.7N/mm^2 > 0.35N/mm^2$

No shear reinforcement required

Deflection check

Actual span/d ratio should be greater than allowable span

Basic span/d ratio = 26

fs $= \frac{2}{3}\times$ fy $\times \frac{\text{Asreq}}{\text{Asprov}}$

fs $= \frac{2}{3}\times 460 \times \frac{576}{628}\times 1 = 281.27$ N/mm^2

Allowable span = $1.16\times 26 = 30.16$

Actual span/d = $\frac{\text{effective span}}{\text{d}} = \frac{4350}{120} = 28.3$

Since actual span/d = 28.3 is less than allowable span/d = 30.16

$\frac{\text{M}}{\text{b.d}^2} = \frac{30.08\times10^6}{1200\times120^2} = 1.74$

Modification factor (Mf):

$$Mf = 0.55 + \frac{477 - fs}{120(0.9 + \frac{M}{b.d^2})} \leq 2$$

$$Mf = 0.55 + \frac{477 - 281.27}{120(0.9 + 1.74)} = 1.16 \leq 2 \text{ ok}$$

The stair is satisfactory with respect to deflection

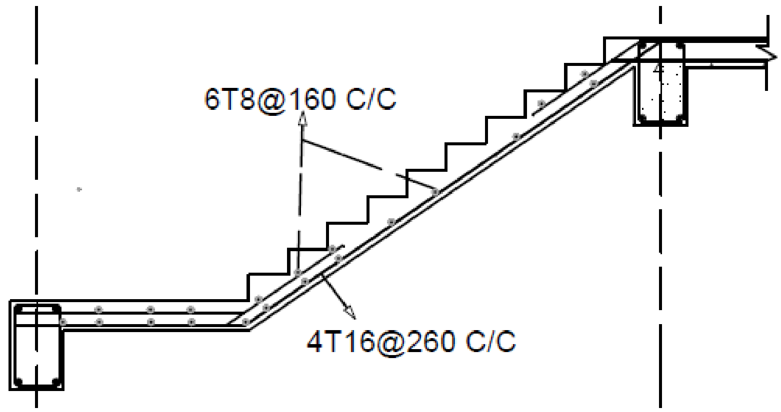


Figure 4. 12:Reinforcement layout of stair slab

4.5. Design of foundation

- **Design of pad foundation**

Specifications and data

The Bearing capacity taken in consideration for my soil is Pb =320KN/m^2 got from National Laboratory for similar building constructed in the area.

fcu = 35N/mm^2

fy = 460N/mm^2

Total load on the column= 663.2915 KN

Design load from the column N = 936.8941KN

Design load from footing= *1.4Gk+1.6Qk +W*

$$1.4Gk + 1.6Qk = 936.894KN$$

The self-weight of the isolated pad foundation (w) is between 10% and 20% of the design load of the column

$$W = \frac{936.894KN * 15}{100} = 140.5341KN$$

- **Procedures and design `**

Service Load (Nd) = 140.5341KN+936.8941KN =1077.4282 KN

Design moment from column=169.357 KNm

Design moment applied on foundation= $\frac{169.357KNm}{2} = 84.6785KNm$

Pmin= $\frac{P+W}{A} - \frac{M+h}{Z}$

Pmin $= \frac{803.8256}{2X2} - \frac{84.6785}{\frac{2X2^2}{6}} = 200.9564 - 63.51 = 137.45\text{KN/m}^2$

$137.45\text{KN/m}^2 > 0$ Safe

Area of the pad foundation: $\frac{Nd}{Pb} = \frac{1077.4282\ KN}{320KN/m^2} = 3.367\text{m}^2$

Dimension: $lx\ and\ ly = (Nd/Pb)^{\frac{1}{2}} = (3.367)^{\frac{1}{2}} = 1.8m \approx 2m$

Let take a square footing of $2m \times 2m$ sides

Design bearing pressure:

$lx = 2m\ and\ ly = 2m$

$e = \frac{M}{P+W} = \frac{169.357KNm}{803.8256} = 0.2m$

$\frac{L}{6} = \frac{2}{6} = 0.3m > 0.2m$ Ok

Pmax= $\frac{P+W}{A} + \frac{M+h}{Z}$, $where\ Z = \frac{b.l^2}{6}$

Pmax= $\frac{803.8256}{2X2} + \frac{84.6785}{\frac{2X2^2}{6}} = 200.9564 + 63.51 = 264.46\text{KN/ m}^2$

Pmax < Pb(bearing capacity) Safe

So, the soil will carry the load safely

- **Design to serviceability limit state**

Maximum and minimum pressure

Design moment applied on footing =84.6785KNm

Design load ignoring the self-weight of footing = 936.8941KN

$P_{max} = \frac{936.8941}{2*2} + \frac{84.6785}{\frac{2*2^2}{6}} = 234.22\ \frac{KN}{m^2} + 63.51KN/m^2 = 297.73\text{KN/m}^2$

Pmin= $\frac{P+W}{A} - \frac{M+h}{Z}$

Pmin= $234.22KN/m^2 - 63.51KN/m^2 = 170.71\text{KN/m}^2$

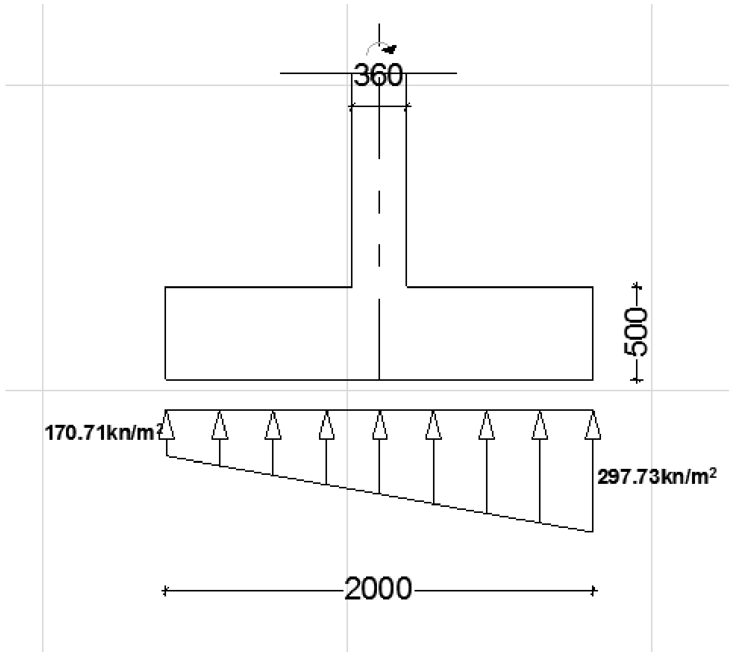


Figure 4. 13:Maximum and minimum pressure

- **Design moment**

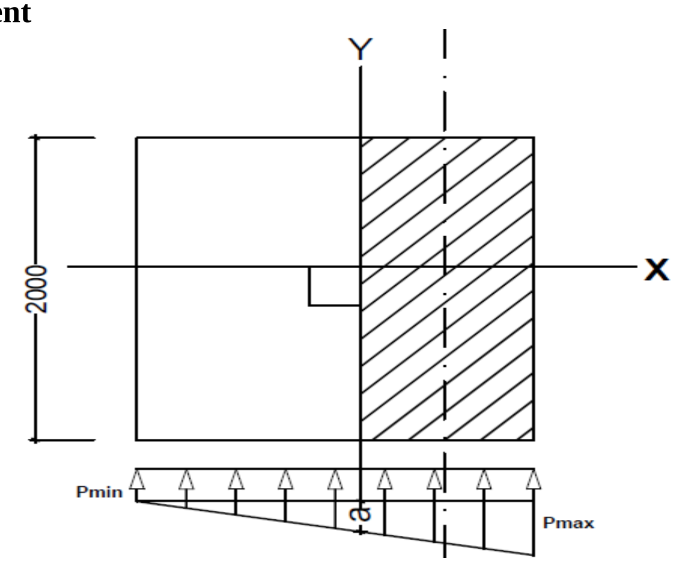


Figure 4. 14:Diagram shows where to find moment of foundation

$$\frac{a}{297.73-170.71 KN/m^2}=\frac{\frac{2}{2}-\frac{0.2}{2}}{2}$$

$$a = 57.159 KN/m^2$$

Maximum pressure= $\frac{170.71KN}{m^2} + KN/m^2 + 57.159 KN/m^2 = 227.869 KN/m^2$

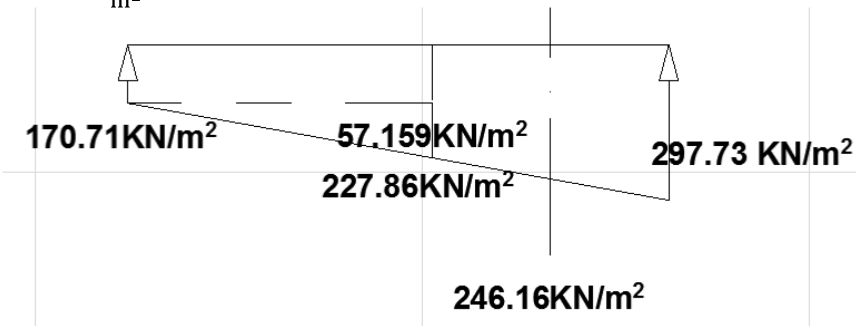


Figure 4. 15:Diagram shows maximum pressure and average pressure where to find moment of foundation

As Lx = Ly maximum moment will be the same in both axis

$$My = 2\left[2-\left(\frac{2+0.2}{2}\right)\right]227.869\times[\frac{2}{2}-(\frac{2+0.2}{4})] = 184.57389KNm$$

The thickness of the footing $=\frac{2+0.2}{4} = 0.55m = 0.6m$

Steel reinforcement in$y - y\ direction$:

$fcu = 35Nmm^2$

$fy = 460Nmm^2$

Cover = 75mm

Diameter of reinforcement: $\emptyset = 20mm$

Assume overall depth = 500mm

Effective depth = $d = h - c - \frac{\emptyset}{2}$

$d = 500 - 75 - \frac{20}{2} = 415mm$

$K = \frac{M}{fcu.b.d^2} = \frac{184.57389\times10^6}{35\times2000\times415^2} = 0.015 < 0.156\quad ok$

No compression bars are required

$z = d[0.5 + (0.25 - \frac{K}{0.9})^{1/2}] \leq 0.95d$

$z = d\left[0.5 + \left(0.25 - \frac{0.015}{0.9}\right)^{1/2}\right] \leq 0.95d$

$z = 407.96mm$

Take $z = 0.95d$

$z = 0.95 \times 415 = 394.25mm$

$As = \frac{M}{0.87.fy.z} = \frac{184.57389\times10^6}{0.87\times460\times394.25} = 1169.83mm^2$

As prov $= 1206\text{mm}^2$ Provide 6T16@100 c/c

As min $= \frac{0.13\times b\times d}{100} = \frac{0.13\times2000\times415}{100} = 1079.\text{mm}^2$

As max $= \frac{0.4\times b\times d}{100} = \frac{0.4\times2000\times415}{100} = 3320\text{mm}^2$

As min $< As < Asmax$

$1079\text{mm}^2 < 1169.83m\text{m}^2 < 3320m\text{m}^2$ The area is satisfactory

Distribution steel

$\frac{3C}{4} + \frac{9d}{4} = \frac{3*200}{4} + \frac{9*415}{4} = 150 + 933.75 = 1083.75$ mm

With C: column width

d: effective depth slab

Lc= the spacing between column centers to the one of edge

So $Lc = 1,$

$Lc < \frac{3C}{4} + \frac{9d}{4} \leftrightarrow 1 < 1.083$

The reinforcement will be distributed uniformly

Reinforcement in foundation

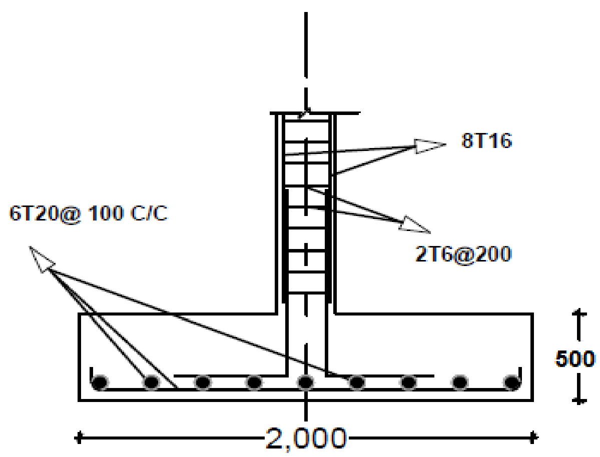


Figure 4. 16:Reinforcement layout in foundation

Vertical shear

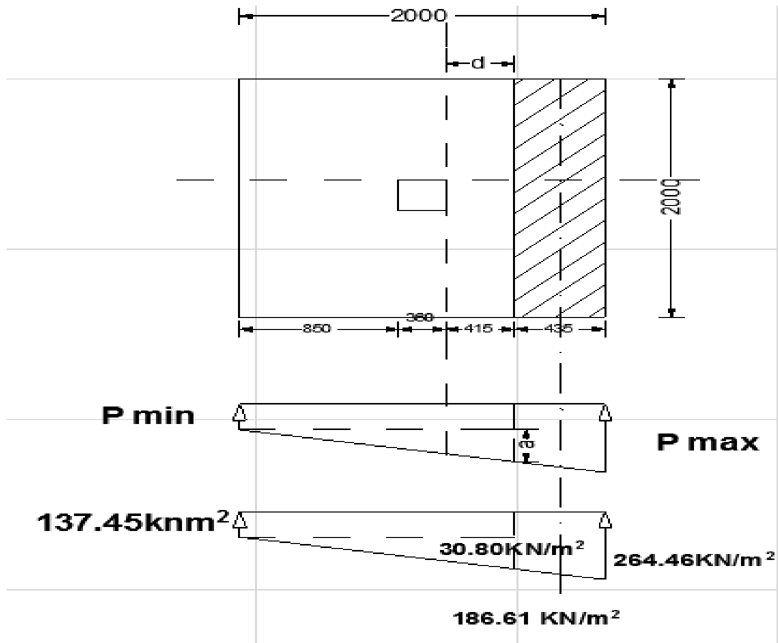


Figure 4. 17:Vertical shear diagram

$\mathrm{d} = 415\mathrm{mm}$

Vertical shear force: the sum of the load acting outside the section considered.

shear stress : $\mathrm{v} = \frac{\mathrm{V}}{\mathrm{Ld}}$, where $\mathrm{L} =$ width of the base

$\frac{a}{297.73-170.71} = \frac{\frac{2}{2}-\frac{0.2}{2}-0.415}{2} =$ $\quad a = 30.80KN/m^2$

Maximum pressure $= \frac{170.71\mathrm{KN}}{\mathrm{m}^2} + 30.80\,\frac{\mathrm{KN}}{\mathrm{m}^2} = 201.51\mathrm{KN/m}^2$

Average pressure$= \frac{170.71+201.51}{2} = 186.11\mathrm{KN/m}^2$

Area $= 2 * 0.485 * 186.11 = 180.53\mathrm{KN}$

Vertical shear check:

$w = \frac{V}{b.d}$

$w = \frac{180.53\times10^3}{2000\times415} = 0.217N/mm^2$

$wc = \frac{0.79(\frac{100\times Asp}{b.d})^{1/3}(\frac{fcu}{25})^{1/3}}{1.25} * (\frac{400}{d})^{1/4}$

$wc = \frac{0.79(\frac{100\times1256}{2000*415})^{1/3}(\frac{35}{25})^{1/3}(\frac{400}{\mathrm{d}})^{1/4}}{1.25}$$=0.37\ N/mm^2$

W<Wc, therefore there are no shear reinforcement required

Punching shear force

$\frac{a}{297.73-170.71}=\frac{\frac{2}{2}-\frac{0.2}{2}}{2}$, $a=57.159\text{KN/m}^2$

Total pressure=57.159KN/m^2+170.71KN/m^2=227.869 KN/m^2

Total area=2*227.869*0.9=410.16 KN

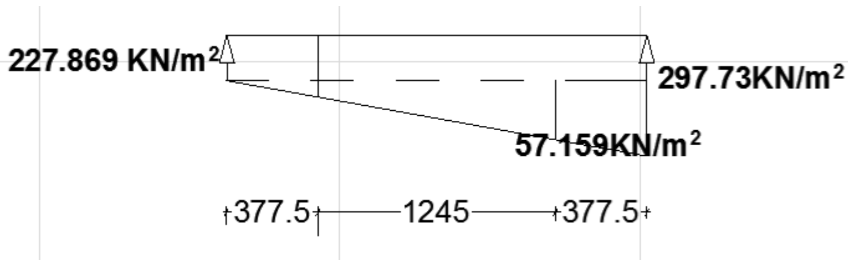


Figure 4. 18:Punching shear diagram

$W=\frac{V}{permiter*d}=\frac{410.16*10^3}{1245*4*415}=0.198N/mm^2$

Maximum shear at face of column

Figure 4. 19:Maximum shear diagram at face of the column

$\frac{a}{2-0.9}=\frac{127.02}{2}$

$a=\frac{1.1*127.02}{2}=69.861\text{KN/m}^2$

$V=\frac{240.571+297.73}{2}*0.9*2=484.47KN$

$W=\frac{484.47*10^3}{2000*415}=0.58\text{N/mm}^2<\begin{cases}0.8fcu^{1/2}\\5N/\text{mm}^2\end{cases}$

$0.58\text{N/mm}^2<5N/\text{mm}^2$

Punching at (1.5d)

Because the area of steel does not exceed 0.3% of the area of foundation, there is no need of crack check

$\frac{0.3}{100} * 2000 * 500 = 3000\ mm^2$

As= $3000mm^2$ >1169.83 mm^2

The bar spacing not exceed 750mm or 3d :

Spacing= $\frac{b-2cover-n*\emptyset MB}{n-1} = \frac{2000-150-16*6}{5} = 350.8mm$

$3d = 3 * 415mm = 1245mm\ ok$

$350.8mm < 1245mm$

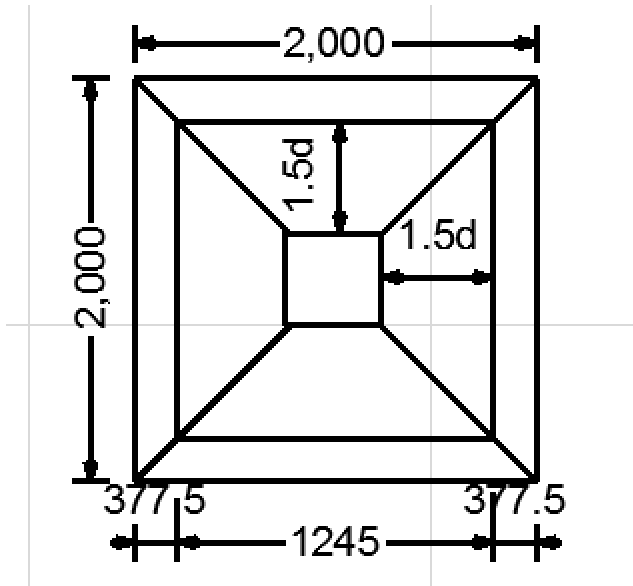


Figure 4. 20:Punching shear diagram at 1.5d

$\frac{a}{2-0.2775} = \frac{127.02}{2}$

$a = \frac{1.7225*127.02}{2} = 109.4\text{KN/m}^2$

$V = \frac{280.11+297.73}{2} + \frac{2+1.445}{2} * 0.2775 = 289.4KN$

$W = \frac{289.4*10^3}{1445*415} = 0.48\text{N/mm}^2 < \begin{cases} 0.8fcu^{1/2} \\ 5N\text{mm}^2 \end{cases}$

$0.48\text{N/mm}^2 < 5N\text{mm}^2$

Punching shear check is satisfactory

Crack check

Because the area of steel does not exceed 0.3% of the area of foundation, there is no need of crack check.

$\frac{0.3}{100} * 2000 * 500 = 3000\ mm^2$

As= $3000mm^2$ >1169.83 mm^2

The bar spacing do not exceed 750mm or 3d:

Spacing= $\frac{b-2cover-n*\emptyset MB}{n-1} = \frac{2000-150-16*6}{5} = 350.8mm$

$3d = 3 * 415mm = 1245mm\ ok$

$350.8mm < 1245mm$

Cracking check is satisfactory.

4.6. Results presentation

The results obtained are given in table below

Table 4. 1:Reinforcement for each structural member

	ELEMENTS	**MATERIALS**		
		CONCRETE	**STEEL**	
			Longitudinal steel	**Transversal steel**
1	Slab	fcu=30N/mm^2	5T12@200 C/C	3T10 @250 C/C
2	Beam	fcu=30N/mm^2	6T20@47 C/C 7T16@28 C/C	2T8@173 C/C 2T8@273 C/C 2T8@280 C/C
3	Column	fcu=30N/mm^2	5T25	T8@200 C/C
4	Stair	fcu=30N/mm^2	8T10@260C/C	6T8@160 C/C
5	Foundation	fcu=35N/mm^2	6T16@100 C/C	6T16 @ 100 C/C

Table 4. 2:BILL OF QUANTITY AND COST ESTIMATION (BOQ)

S/N	ITEM	UNIT	QTY	RATE	TOTAL AMOUNT
I	**PRELIMINARY WORK**				
1	Demolition and site clearance	**Ls**	1	3,500,000	3,500,000
2	site installation	**Ls**	1	2,400,000	2,400,000
3	Site compaction	**Ls**	1	4,000,000	4,000,000
4	Site survey	**Ls**	1	1,720,000	1,720,000
	sub-total				**11,620,000**
II	**SITE PREPARATION**				
1	Earth work in full mass for topsoil	cum	1856	3,000	5,568,000
2	Excavation for foundation	cum	126	3,000	378,000
	sub-total				**5,946,000**
III	**FOUNDATION**				
1	Blinding concrete of 5cm thick	sqm	210	20,000	4,200,000
2	Stone masonry with cement mortar	cum	86	60,000	5,160,000
3	Damp proof coarse	msq	240	2,000	480,000
4	Footing for columns	cum	41.16	350,000	1,440,6000
	sub-total				**24,246,000**
IV	**REINFORCED CONCRETE**				
1	Square columns	cum	4.9	350,000	1,715,000
	Rectangular columns	cum	89.12	350,000	31,192,000
2	Ring beam	cum	14.45	350,000	5,057,500
3	Beam	cum	45.34	350,000	15,869,000
4	Stair	cum	20.62	350,000	7,217,000
5	Slab of 20 cm thick	cum	112.2	350,000	39,270,000
6	Ramp	cum	12.36	350,000	4,326,000
	sub-total				**81,560,500**
IV	**MASONRY**				
1	Brick work	cum	252.42	80,000	20193600
V	**ROOF**				

1	Roof trusses	Ls	1	40,000,000	40,000,000
2	Roof covering	Ls	1	22,000,000	22,000,000
	Sub-total				**62,000,000**
VI	**CEILING**				
1	Ceiling with gypsum	m^2	120.46	25,000	3,011,500
	Sub-total				
VII	**DOORS AND WINDOWS**				
1	Aluminum double doors	piece	10	380,000	3,800,000
2	Single Flush doors	piece	10	300,000	3,000,000
3	Single flush doors for toilets	piece	26	150,000	3,900,000
4	Aluminum larger windows	piece	53	240,000	12,720,000
5	Aluminum smaller windows	piece	10	200,000	2,000,000
	sub-total				**25,420,000**
VIII	**PLASTERING**				
1	Primary coat	m^2	1440	6,000	8,640,000
2	Rendering coat	m^2	1440	6,000	8,640,000
3	Finishing coat	m^2	1440	8,000	11,520,000
	sub-total				**28,800,000**
IX	**PAVEMENT AND FLOOR FINISH**				
1	Concrete pavement 10cm thick	cum	32.80	100,000	3,280,000
2	Smoothened pavement 5cm thick	m^2	16.40	10,000	164,000
3	Flooring tiles 50mm * 50mm	m^2	320	30,000	9,600,000
4	Timber for steps on fans seats	Ls	-	24,000,000	24,000,000
5	Basketball playing cmyt surface finishing	Ls	**-**	32,000,000	32,000,000
	sub-total				69,044,000
X	**PAINTING**				
1	Enamel paint on walls	m^2	1440	4,200	6,048,000
2	Oil paint on balustrades roof truss	m^2	174	4,500	783,000
	Enamel paint on rectangular columns	m^2	128	4,200	537,600
3	Enamel paint on square columns	m^2	23	4,200	96,600

	Sub-total				**7,465,200**
XI	**BUILDING SERVICES**				
1	Air conditioning	piece	64	540,000	34,560,000
2	Fire extinguishers	piece	52	35,000	1,820,000
3	Chairs for fans and players	piece	1264	12,000	15,168,000
	Sub-total				**51,548,000**
XII	**Gates**	piece	2	1,200,000	2,400,000
XIII	**Parking**	m^2	400	15,000	6,000,000
XIV	**Garden**	m^2	750	2,000	1,500,000
XV	**Water tank (10,000L)**	Piece	4	1,400,000	5,600,000
	Sub-total				**15,500,000**
THE TOTAL COST					**614,105,700**

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the purpose of this project of architectural and design of G+1 of gymnasium in ULK KIGALI, the objective set as the beginning of research and develop of ULK KIGALI campus, without ignoring the extension of the number of students per year corresponding to increase of department, this sport facility will host 1300 spectators (fans) with their seats.

This project will solve the problem of missing complete equipped sport facility needed by the user for playing, making physical exercise and relaxing that is need.

Inc6 case this project not complemented there many negative effects facing developmennt and organization that will be main cause of postponement of some games or other events.

5.2. Recommendation

I would like to make recommendation to

- To improve the way of learning the engineering software as they are most used in final year project and in dail life of engineers.
- To the engineers before construction, they have to make soil test of proposed project according to structural design to make sure soil have capacity to support the loads
- To ministry of sport and sport partners to support this project to be implemented.
- To teams of those who are interested in sports and entertainment to identify and recover their talent in this new sport facility that will be comfort in different sides of every kind of sport.

REFERENCCES

Ali, M. M., & Al-Kodmani, K. (2019). Tall buildings and urban habitat of the 21st century: A global perspective. *Buildings*, *9*(2), 40.

Arya, C. (2019). The structural design of elements: Concrete, steelwork, masonry and timber designs to British Standard and Eurocodes (4th ed.). CRC Press.

Brock, L., & Brown, J. (2021). The architect's guide to the US National CAD Standard. Wiley.

Chatterton, M. (2020). The management of sustainable building services. Routledge.

City of Kigali. (2022). The Kigali master plan 2040.

Demkin, J. A. (Ed.). (2021). The architect's handbook of professional practice (16th ed.). John Wiley & Sons.

Hibbeler, R. C. (2018). Structural analysis (10th ed.).

Klimoski, E. (2020). Construction documents: Developing processes and procedures for effective processing. Routledge.

Levy, S. M. (2018). Project management for construction (7th ed.). McGraw-Hill Education.

Love, Peter E. D, Edwards, D. J. and Iran, Z. (2023). Emerging technologies and construction projects: A review regarding design creativity optimally in constructed space without containment and plagiaries. Construction Management and Economics.

McCormack, J. C. & Brown, R. H. (2020). Reinforced concrete design (10th ed.). Wiley.

McGuire, M. and Schaffer, W. (2021) The architecture reference & specification book: everything architects should know on a daily basis (2nd ed.). Rockport Publishers.

Nilsson, A. H., Darwin, D., & Dolan, C. W. (2021). Design of concrete structures (16th ed.). McGraw Hill.

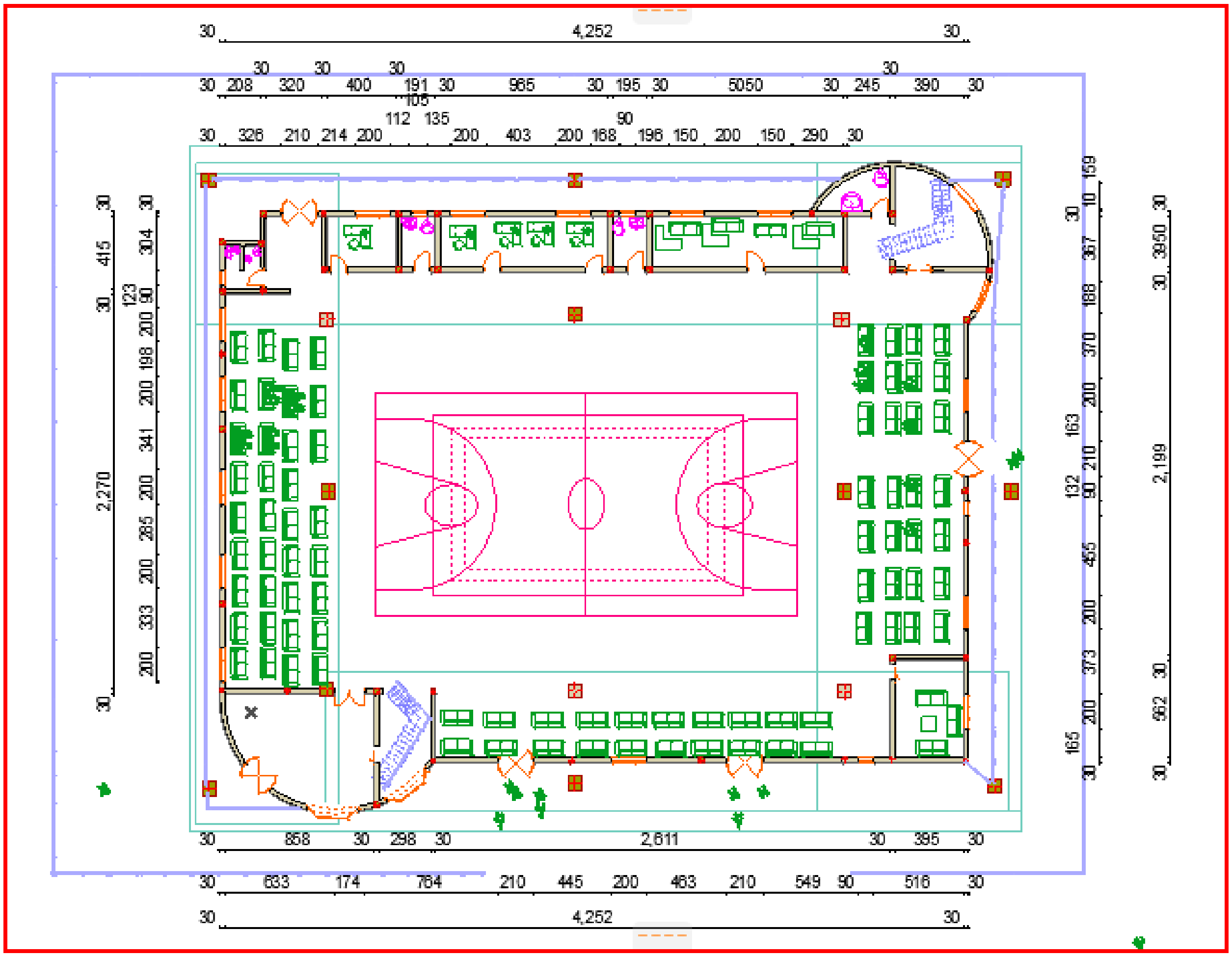
Pressman, A. (2018). Designing architecture: The elements of process. Routledge.

Satterthwaite, D. (2019). The new geography of poverty in cities. Environment and Urbanization.

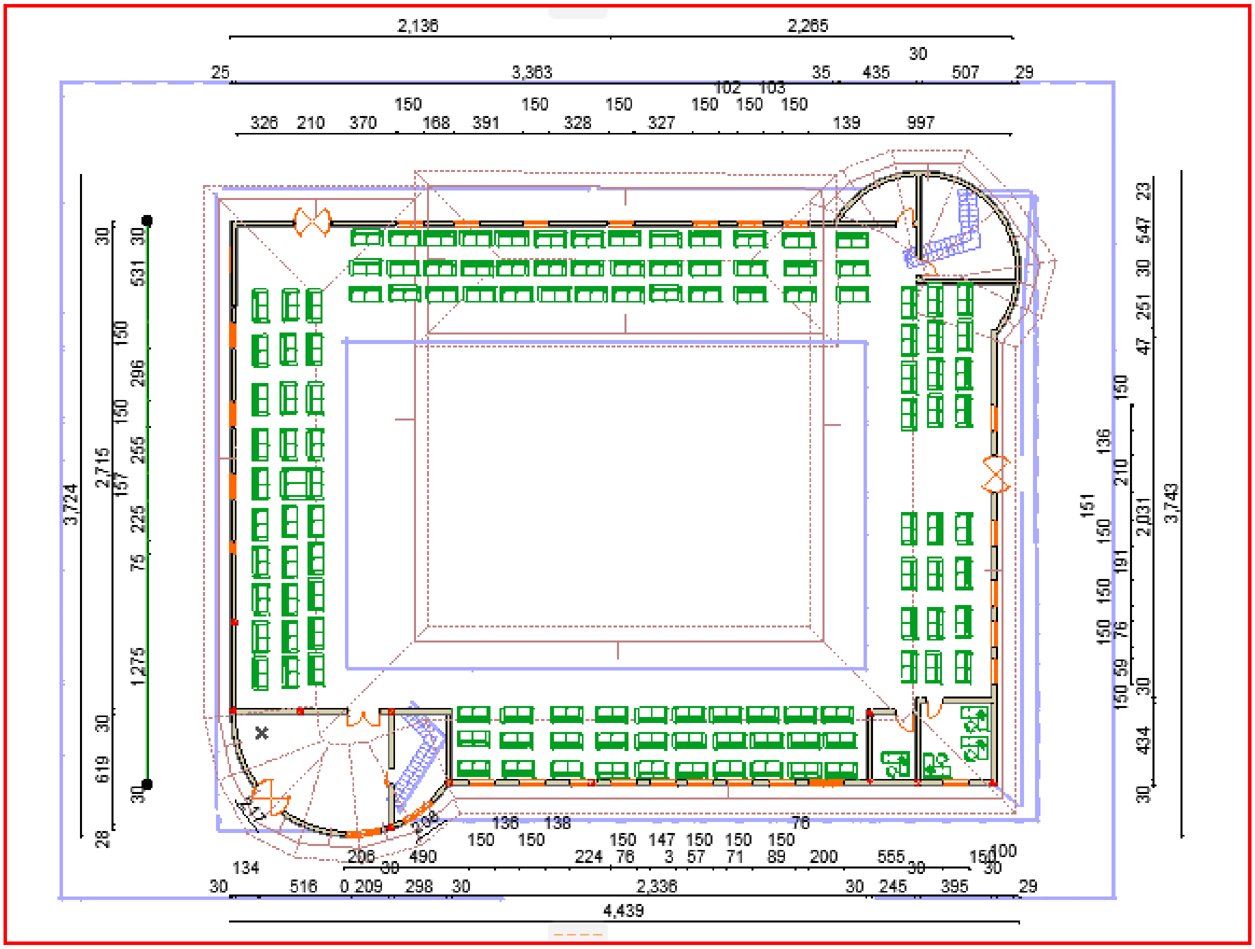
Tamboli, A. R. (2020). Tall and supertall buildings: Planning and design. McGraw Hill Professional.

APPENDICES

APPENDIX 1)Ground Floor

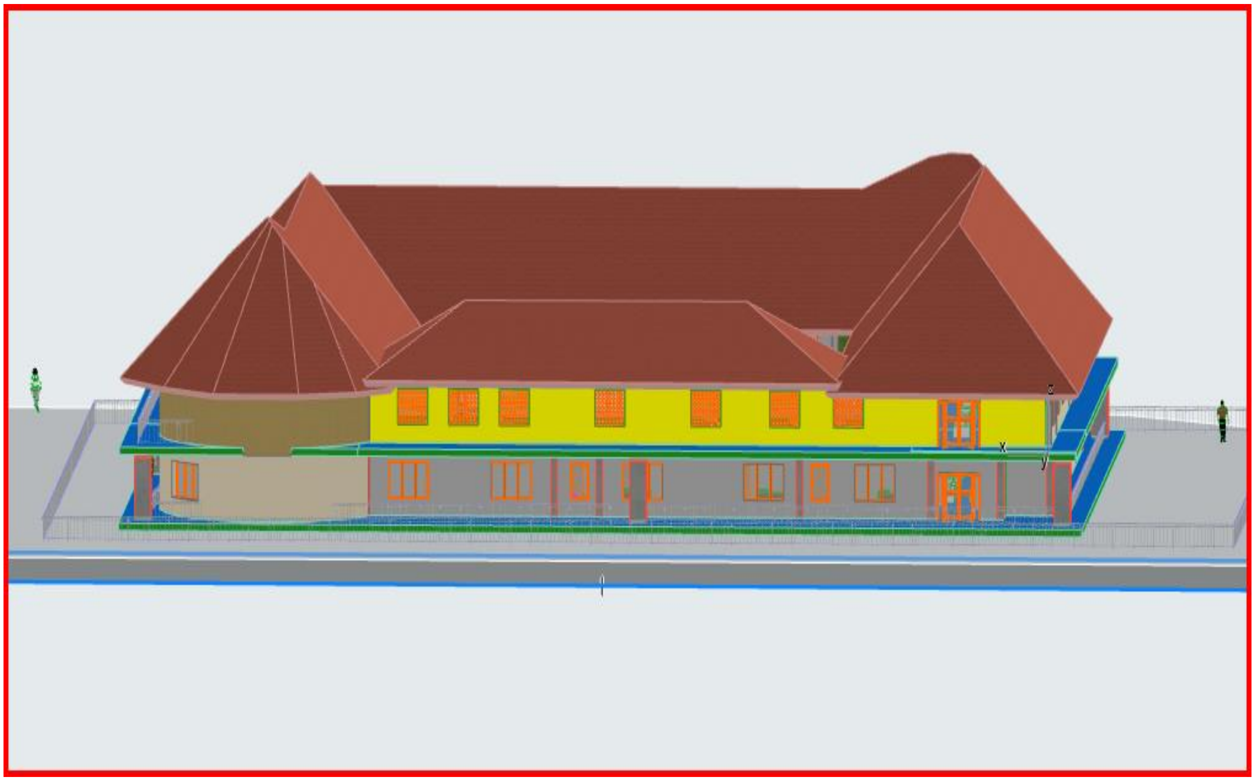


APPENDIX 2)1st FLOOR

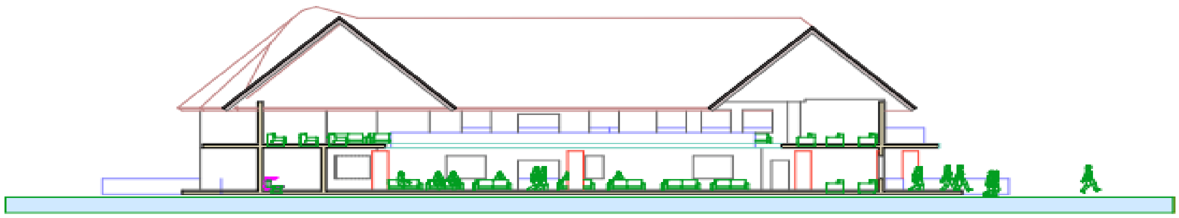


APPENDIX 3)Front view perspective

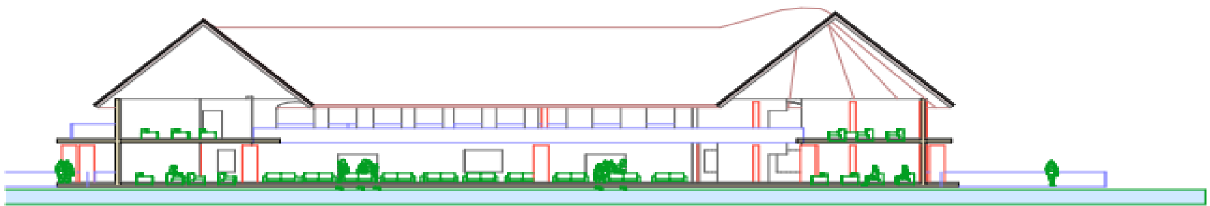
APPENDIX 4)Back view perspective



APPENDIX 5)SECTION



SO1 BUILDING SECTION



SO2 BULDING SECTION

APPENDIX 6)Roof plan