REPUBLIC OF RWANDA

ULK POLYTECHNIC INSTITUTE

P.O.BOX 2280 Kigali

Website: //www.ulkpolythechnic.ac.rw

E-mail:polytechnic.institute@ulk.ac.rw

DEPARTMENT OF CIVIL ENGINEERING

OPTION: CONSTRUCTION TECHNOLOGY

STRUCTURE DESIGN OF PUBLIC LIBRARY G+3
CASE STUDY: GASABO DISTRICT, GISOZI SECTOR.

Submitted in partial fulfillment of the requirement of the award of Advanced Diploma in Construction Technology

Presented by: **Wakilongo Kamwanga**

Roll number: **202150406**

Under the guidance of **Eng**. NKIRANUYE Bonaventure

Kigali, **September**, 2024

DECLARATION

I do hereby declare that this project entitled "Architectural and structural design of a four stores Public Library" work presented in this dissertation is my own contribution to be the best of my knowledge. The same work has never been submitted to any other University or Institution. I, therefore declare that this work is my own for the partial fulfilment of the requirements for the Advanced Dįploma in Civil engineering department, Option of construction technology at Ulk Polytechnic Institute

The candidate's name: Wakilongo Kamwanga

Signature of the candidate: ………………………

Date of submission: …/……/…...

APPROVAL

This is to certify that this dissertation work entitled architectural and structure design of four-stores Public Library building in Gasabo district, Gisozi Sector is an original study conducted by Wakilongo Kamwanga and has been submitted with the approval of Supervisor under His guidance.

Supervisor: Eng. NKIRANUYE Bonaventure

Signature: …………………………………….

Date………/………./2024

DEDICATION

Dedicated to
To my beloved parents
To my brothers and sisters
The work in this dissertation is nicely
To my relatives, friends and classmates
To my terra and my workmate

ACKNOWLEDEMENTS

I praise God, the Almighty for everything that happened in my life. This precious dissertation has been completed successfully. Thanks to the support of several people who assisted and guided me in many ways. I am forever grateful to my family for sponsoring all my studies; they cared and invested the most in everything that matter to me. I would like to thank the entire administration of Ulk Polytechnic Institute and its academic staff particularly those who have been my lectures in the department of civil engineering for their advance preparations and lucid explanations in the courses that they lectured which helped me to build the skills and knowledge in civil engineering. Eventually, I want to express my gratitude and deepest appreciation to my project supervisor Eng. NKIRANUYE Bonaventure and all my classmates especially those who never stopped giving the reasons to keep working hard.

MAY GOD BLESS YOU ALL!

ABSTRACT

This research project was conducted for the purpose of proving architectural plans and structural details of a four-story Public Library building in Gasabo district, Gisozi Sector. To achieve efficiently this project's goal, some methods have been used like ArchCAD for architectural drawings different elevations, sections, perspectives and structural design for involve the size of different component of structural members slabs, columns, foundations and stair, AUTODESK ROBOT, have been used for the design of beam, and reinforcement Google earth have been used for well locating the study area so used by Long wall-short wall method for getting the cost of the project in this method, the wall along the length of room is considered to be long wall while the wall perpendicular to long wall is said to be short wall. The results showed that architectural design of building accommodates 100 person each floor have 25 person and structural design of this project shown that the design steel reinforcement to be arrangement in slab were 5 bars of 10mm of diameter per meter 5Φ10/m at the top and 5Φ10/m at the bottom while for beam the designed steel reinforcements were 4Φ16 at the top and 4Φ14 at bottom. And for column the designed steel reinforcement were 6Φ25for ground floor part of the column and 6Φ25 for first 4ф16 for and third floor part of the column for foundation the designed steel reinforcement were 5Φ14/m while for stair the designed steel reinforcement were 6Φ10/m distribution reinforcements the safety of the building have been well insured by comparing the load from the super structure. The cost of construction of proposed building was estimated (750,500,000 Rwf). The execution of this project would stimulate proper land use; solve the problem of current public library operates only during regular working hours.

Keywords: Architectural design, Structural Design, and bills of quantity.

LIST OF SYMBOLS AND ABREVIATIONS

∆q: balanced punching shear force

Ab: Average lateral area of the punching pyramid

As: Cross sectional area of tensile reinforcement

As': Cross sectional area of compression reinforcement

Asv: Area of steel in links

B: Effective breadth

Bf: Width of flange in a beam

Bw: Width of web in a beam

D.L: Dead load

Df: Depth of foundation

F.S: Safety factor

Fcu: Characteristic yield strength of concrete

Fvy: Shear force

Fy: Characteristic yield strength of steel

G: going

Hf: depth of the slab

Ho: effective depth of the cross section

Kg: Kilogram

L.L: Live load

Lx: The length of the shorter side

Ly: The length of the longer side

M+X: design moment from the bottom at the shorter side

M+Y: design moment from the bottom at the longer side

MX: design moment from the top at the shorter side design from the top at the longer side

Nf: load transmitted by column into foundation

P: total distributed load

Qf: punching shear force

R: rise

Rb: design concrete compression strength

Rcc: reinforced cement concrete

Rs: design steel tensile strength

T: Thickness

Um: average perimeter of the punching pyramid

αm: coefficient taking into account the bending moment action

ζ: slenderness ratio

ζR: maximum value of ζ

ф: diameter of steel reinforcement

Ulk: Universite Libre de Kigali

UPI: Ulk Polytechnic Institute

Table of Contents

List of figures

List of table

LIST OF APPENDICES

CHAPTER 1: GENERAL INTRODUCTION

1.1. Introduction

This chapter will talk about the background of the study, the problem statement, the main and specific objectives, scope and limitation the significance of the study and organization structure.

1.2. Background of the study

In earliest time there was no distinction between a record room or archive and a library, but nowadays libraries can be said to have existed for almost as long as record have been kept. The world's oldest known library is Ashurbanipal was founded some time in 7th century b.c, is located in Nineveh in modern day Iraq. (ANDREWS, 2018)

In Rwanda library was founded in 1989 by the presidential, order no 132/06 of March 10th 1989 as a directional in a ministry of high education and research. It is located in Kigali city. (MUTAMBA, 2015)

1.3.Problem statement

In Kigali, the current public library operates only during regular working hours, closing at 17:00. This schedule poses significant challenges for students and working professionals who are unable to access the library after their classes or work. To address this issue, I propose the establishment of a new public library that operates 24/7, ensuring accessibility for all Rwandans and even foreign visitors. The primary goal of this project is to create a public library that is accessible at all times, providing a conducive environment for reading, research, and learning. This library will cater to the needs of students, professionals, and the public, promoting a culture of continuous learning and intellectual growth. This 24/7 public library will be a valuable addition to Kigali, addressing the current accessibility issues and supporting the educational and research needs of the community. By providing a welcoming and resource-rich environment, the library will contribute to the intellectual and cultural growth of Rwandans and visitors alike.

The library will be strategically located in Gisozi, an area known for its diverse institutions and educated populace. This location will make it convenient for students, researchers, and professionals to access the library's resources.

1.4. Objectives

1.4.1. Main objectives

Main objective of this project is to do Structural design of G+3 Public library.

1.4.2. Specific objectives

The specific objectives of the project to achieve main objective are as follow:

1. To carry out site investigation on the site
2. To perform Architectural drawing.
3. To perform Structure design.

1.5 Significance of the study

1.5.1. Personal Significance.

In order to get the degree of relevancy, the class theories to be paralleled with the genuine practical skills on the field. Thus, the following interests are targeted:

This research work is primarily designed to contribute to the role of architectural and structural design of multi-story building of Public Library as such we are interested in studying, developing professional in my future career as technician; to get civil engineering skills; to get individual development skill in daily life.

1.5.2. Academic Significance.

As a student who is ending up undergraduate level in the Faculty of construction technology especially in civil engineering, my research will help me to deepen my studies and this will be used by other students who will be interested in this field and will find this document in GISOZI public library.

1.5.3. Social Significance.

- ✓ This project will promote economic development of the country.
- ✓ This project will generate employment for the people.
- ✓ This project will increase the economics of visit Rwanda people cam to see the beauty of 1000 hills

1.6. Scope and limitation

In this project, there are some works, which can be excluded such as:

- Cost and estimation
- Site layout
- Electrical drawing
- Sanitary drawing
- Cctv drawing
- Site plan

Limitation of research project

Due to financial statement and limited time, the present project does not include: Soil test, the installations design like electrical, telephonic and plumbing installations, rainwater harvesting, septic tank design and sound insulation, internet work fire alarm system

1.7. Organization of The Study

This project is made by 5 chapters where: chapter 1 will be talking about the General introduction including background of the study, problem statement, objectives, significance of the project, scope and delimitation of the study.

Chapter 2 is the literature review will includes the theories related to the structural design, analysis and the materials of construction with their properties.

Chapter 3 is the Materials and Methods and this gives the information about site location different methods used to know information about calculations and the standards to be used during design.

The chapter 4 is the Results, discussion will deal with the results of structural design, analysis and calculations and discussion about results, chapter 5 is the conclusions, and recommendations will state the output of the project and give some suggestions.

CHAPTER2: LITERATURE RIVIEW

2.0. Introduction

The design and construction of a G+3 (Ground plus three floors) public library in Kigali City, specifically in the Gisozi sector, requires a comprehensive understanding of architectural principles, structural engineering, and local context. This literature review aims to provide an overview of existing research and best practices related to the structural design of multi-story public libraries. A public library is a community-focused institution that provides free access to a wide range of resources, including books, digital media, reference materials, and other educational tools. It is an essential public services aimed at fostering education, literacy, and cultural enrichment. A public library serve as accessible space for individuals of all ages, backgrounds, and socioeconomic statuses to engage in reading, learning, and personal development.

2.1. Key facilities and general requirement for Public Library Building.

1. Sanitary facilities

The Public Library Building must include sanitary facility located in the unit. The sanitary facilities must be in the proper operating condition, and adequate for personal cleanliness and the disposal of human waste. The sanitary facilities must be usable in privacy (Tompkins et al., 2010).

2. Interior quality

The Library unit must have capable of maintaining thermal environment health for the human body. The windows and other openings must be well sized and oriented in good orientation and provide air conditioning to make more comfortable (Lan et al., 2011).

3. Water supply

The water supply must be free from contamination with proper operation condition and well installation.

4. Drainage system

The wastewater from the plot of the Library must be well drained and the water harvesting system is more helpful.

5. Access performance

The Public Library Building must be able to be used and maintained with the provision of the alternative means of exist case of any bad hazard event (Wilbur et al., 1933).

6. Safe in structure and material

The Public Library Building must be well structured and must protect the occupants from the environment. The used materials have to be well examined to ensure that they have any worse effect on the tenants (Zimmerman, 2001).

2.2. Architectural Dimensions

2.2.1. Partitions

The size of the room depends on equipment needed in that room that is why not all the rooms are equal in size as not designed for the same purpose. The size of equipment influence the size of the room is much helpful because the more the room is well sized the more the comfortability of their tenants increase because all the possible movements and necessary equipment have been taken into account more the size of the room that will be needed to contain that equipment (Panero, 1979).

2.2.2. Architectural dimension standards for the Public Library Building

Library is a generally a room or other area where work is done, but may also denote a position within an organization with specific duties attached to it. Every room where persons work will have sufficient floor area, health and unoccupied space for purpose of health, safety and welfare. While architectural conceptualization, the following dimensions should be taken into consideration (Van, 2000).

2. 3. Structural construction material

2.3.1 Concrete

Concrete is composite manufactured material, is the most widely used in building material in the construction industry. It consists of rationally chosen mixture of binding material such as lime or cement, well graded fine and coarse aggregates, water and admixture when is necessary (Carino, 1994).

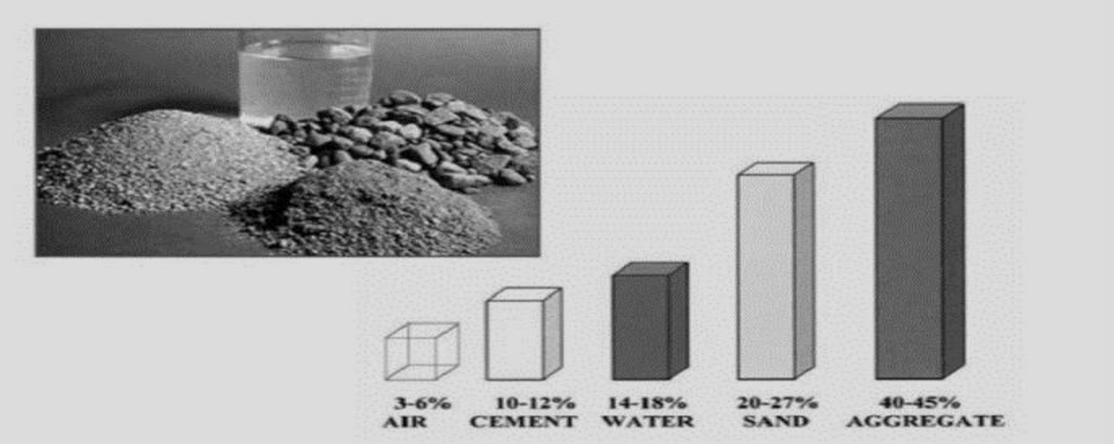


Figure2. 1. ***Constituent of concrete***

2.3.1.1. Cement

Cement is general sense are adhesive and cohesive materials which are capable of binding together particles of solid matter into compact durable mass. For civil engineering works, they are restricted to calcareous cements containing compound of lime as their chief constituent, its primary function being the bind the fine (sand) and coarse (grift) aggregate particle together. Cement used in construction industry may be classified as hydraulic (include Portland cement which is the most common type of cement in used) and non-hydraulic (Blezard, 2004).

2.3.1.2. Aggregate

Aggregates are the basic material used as filler with binding material in the production of mortar and concrete. To increase the bulk density of concrete aggregates are used in two markedly different size the bigger one known as the coarse aggregate (grift) and the small one fine aggregate (sand). The coarse aggregate from the main matrix of concrete and the fine aggregate from the filled matrix between the coarse aggregate, they should be clean, hard, strong, durable and graded in size to achieve maximum economy from the paste (Fookes, 1980).

2.3.1.3. Water

The purpose of using water with mix is to cause hydration of the cement. Water in excess of that required for hydration act as a lubricant between coarse and fine aggregates and produces a workable and economical concrete. But amount of water must be limited to produce concrete of the quality required for job. Water is also used for washing aggregate and curing (Demirbas, 1996).

2.3.1.4. Admixture

The admixtures are substance introduced into a batch of concrete, during or immediately before mix it for to improve their property. There are many type of admixtures, there are: air-entraining agents, retarders, water reducers or plasticizers and super plasticizers (Mailvaganam, 2002).

2.3.1.4. Reinforcement

Cement concrete is one of the most versatile and established construction material throughout the world. Concrete being extremely weak in tension requires reinforcement, which is invariably steel. Steel reinforcement is available in the form of bars of specific diameter with different chemical composition, e.g., mild steel, high tensile steel and surface characteristics (plain or deformed). The pair or bundle is taken as a single bar of equivalent area, bars are available with diameter of 6, 8, 10, 12, 16, 20, 25, 32 and 40mm. reinforcing bars are produced in two grade hot rolled mild steel of characteristic strength of 250N/mm^2 and hot rolled high yield steel bars of characteristic strength of 450N/mm^2 (Condit, 1968).

When steel is exposed to atmosphere, it is subjected to action of atmospheric agencies. The humid air causes the rusting of steel (the formation of oxides on the surface of steel), also the atmospheric condition along with rain produce oxidation and corrosion. Consequently, the physical and mechanical properties are affected (Currie et al., 1983).

2.3.2. Property of reinforced concrete

Table 1: ***Property comparison of steel and concrete (Maslehuddin et., (2003).***

Property	Concrete	Steel
Strength in tension	Poor	Good
Strength in compression	Good	Good but not slender bars
Strength in shear	Fair	Good
Durability	Good	Good but corrodes if unprotected
Fire resistance	Good	Poor at high temperature

It can be seen from this list that the materials are more or less complementary. Thus when they are combining the steel is able to provide the tensile strength and probably some of the shear strength while the concrete strong in compression, protect the steel to give it durability and fire resistance invalid source specified.

2.3.2.1. Composite action

The tensile strength of the concrete is only about 10% of its compressive strength. Because of this, nearly all reinforced concrete structure is designed on the assumption that the concrete does not resist any tensile forces, modulus of elasticity, and the short-term stress stain curve for concrete in compression shown in fig.2. The slope of the initial straight portion is the initial tangent modulus. At any point P the slope of curve is the tangent modulus and the slope of line joining P to the origin is secant modulus depends on the stress and rate of application of the load (Choo et al., 2002).

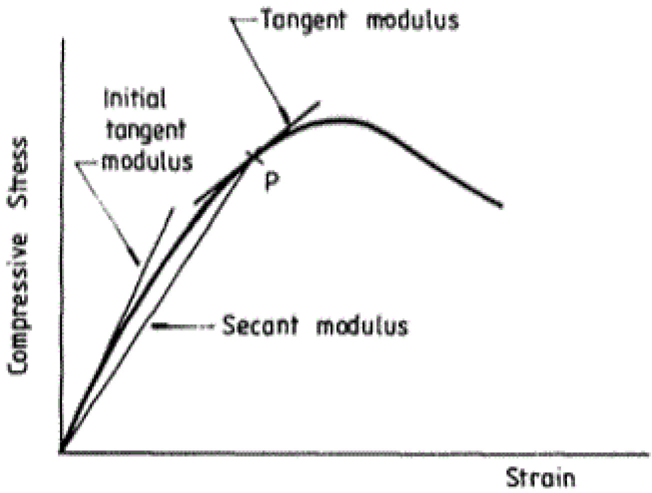


Figure2. 2. ***Stress-stain curve(Marsh & Campbell, 1963).***

The redistribution of load is caused by change in compressive strains being transferred to the reinforcing steel. Thus the compressive stresses in the steel are in creed so that the reinforcing steel is increased, so that the steel take a larger proportion of the load. The effect of creep is particularly important in beams the increased defection may cause the opening of cracks, damage to finishes, and the non-alignment of mechanical equipment redistribution of stress between concrete, occurs primarily in the in cracked compressive area, and has little effect on the tension reinforcement other than reducing shrinkage stress in same instance.

The provision of reinforcement in the compressive zone of flexural member, however, often helps to restrain the deflection due to creep invalid source specified.

2.3.2.2. Durability

Concrete structures properly design and constructed, are long lasting and should require little maintenance; the durability of concrete is influenced by:

1. The exposure condition

2. The cement type
3. The concrete quality
4. The cover to reinforcement
5. The width of any cracks

2.3.2.3. Shrinkage

Shrinkage is the contraction occurs in concrete when dries and hardens. Drying shrinkage is irreversible but alternate wetting and drying cause expansion and contraction of concrete. The Aggregate type and content are the most important factor influencing shrinkage. The large size of aggregate is, the lower is the shrinkage; is low workability and to cement ration are. Aggregate change the volume on wetting or drying, such as sand stone or basalt; give the concrete with the larger shrinkage strain. While non shrinking aggregate aggregates such as granite or gravel gives lower shrinkage. a decrease in the ambient relative humidity also increase shrinkage (Choo et al., 2006)

2.3.2.4. Creep

Creep in concrete is gradual increase in strain with time in member subjected to prolonged stress. The creep strain is much larger than the elastic strain on loading. If specimen is unloaded there is an immediate elastic recovery and a slower recovery in the strain due to creep. Both amount of recovery much less than original strain under loading. The main factor affecting creep in concrete are concrete mix and strength, the type of aggregate, curing, ambient relative humidity and the magnitude and duration of sustained loading (Mosley et al., 1990).

2.3.3. Brick materials

One of the oldest building material brick continues to be a most popular and leading construction material because of being cheap, durable and easy to handle and work with. Brick may be made of burnt clay or mixture of sand and lime of Portland cement concrete. Clay brick are used for building-up exterior and interior walls, partition, pier, footing, and other load bearing structures (john, 2010).

2.3.4. Stone material

Stone has been used in the construction of most of the important structure since prehistoric age such as pyramid of Egypt, Great wall of china and etc. it been defined as the natural, hard substance formed from mineral and earth material which are present in rocks. Stone can serve: to construct the foundation and wall items; to manufacture element of stair, landings, parapets and guardrails; and it can also be used as flooring material (John, 2010)

2.3.5. Mortar materials

Mortar is a mixture of sand and lime or a mixture of cement with or without lime. The mortar used in brickwork transfers the tensile, compressive and shear stresses uniformly between adjacent bricks. The mortar can also be used to join stone and block.

2.4. Analysis of structure theory

The objective of analysis of structure is to determine the axial forces and moments throughout the structure. A reinforced concrete structure is combination of beams, column slabs and walls rigidly connected together to form a monolithic frame. Each individual member must be capable of resisting the force acting on it, so that the determination of that force is an essential part of the design process. The full analysis of a rigid concrete frame is rarely simple; but simplified calculation of adequate can often be made if the basic action of structure is understood. The analysis must begin with an evaluation of all the loads carried by the structure, include the own weight. First, the structure itself is rationalized into simplified forms that represent the load-carrying action of the prototype. The forces are one of the following methods can then determine each member: applying moment and shear coefficients, manual (analytical) calculation and computer method. In this project, all three methods are used (Ghali et al., 2017).

2.4.1. Design procedure

Structural design is the task done in order to give the structure the safety in its expecting life so that the structure could not became unfit by collapse, overturning, buckling, excessive deformation, cracking etc., designing consist the series of procedures that the designer must follow. Here, there is the flow chart diagram that summarizes the guideline in designed concrete structure (Blockley, 1980).

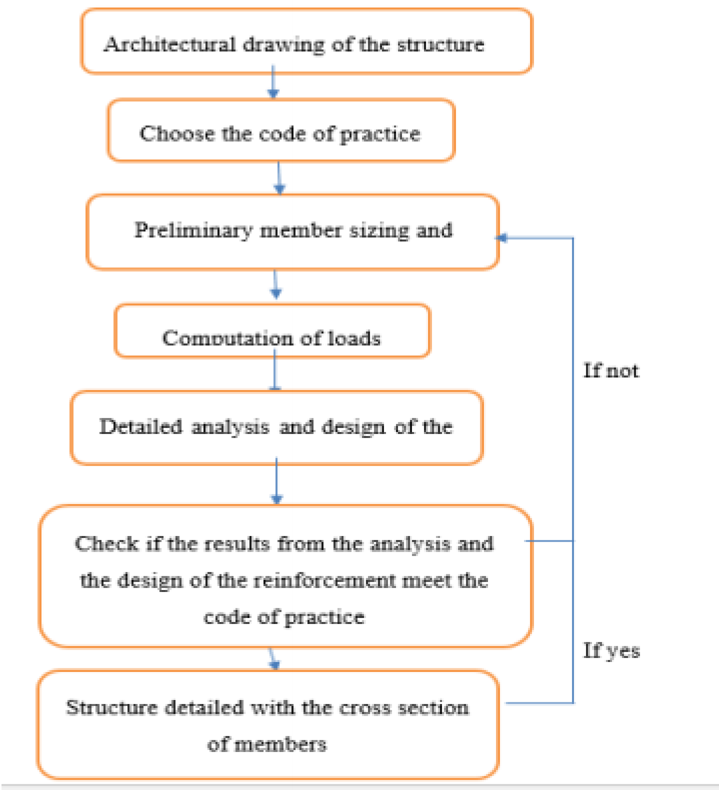


Figure2. 3. ***Flow chart diagram of reinforced concrete structure design (Blockley, 1980).***

2.5. Characteristic of loads

The characteristic or service loads are the actual loads that the structure is designed to carry. These loads must not be exceeded at 95% of probability, during the design life of the structure generally, loads on civil engineering structure fall into two categories: dead loads and imposed loads. But also there is another type of load which is dynamic or wind loads (MacGregor, 1997).

2.5.1. Dead loads on structure

Dead load or permanent loads (Gk) are loads that can act on structure all the time and includes it self-weight, fixture, such as service duct and light fitting, suspended ceiling, cladding and floor finishes (MacGregor,1997).

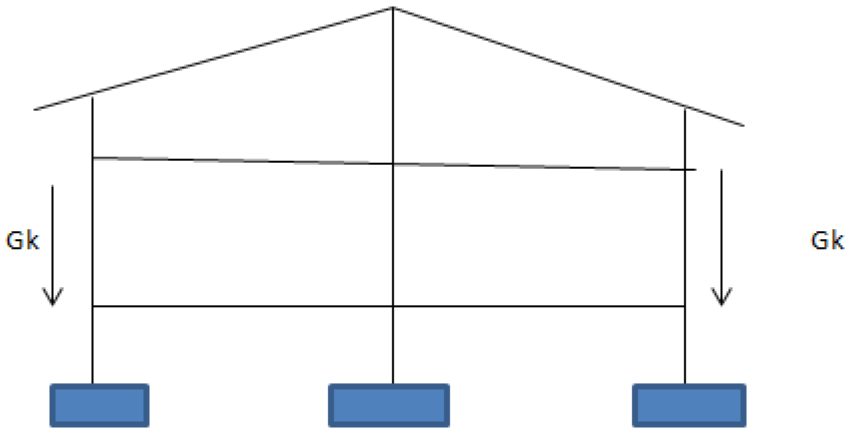


Figure2. 4. Dead loads(MacGregor, 1997).

2.5.2. Live loads or imposed loads to as live loads

Imposed loads, same time also referred to as live loads, represent the load due to proposed occupancy and include the weight of occupants, furniture and roof loads including snow. Since imposed loads tend to be much more variable than the dead loads they are more difficult to predict. In most case, codes of practice specify value of above loads, which must be in design. These value, however, are usually multiplied by factor of safety to allow for uncertainties; generally, the factor of safety used for live loads tend to be greater than these applied to dead loads because live loads are more difficult to determine accurately (Alden, 2011).

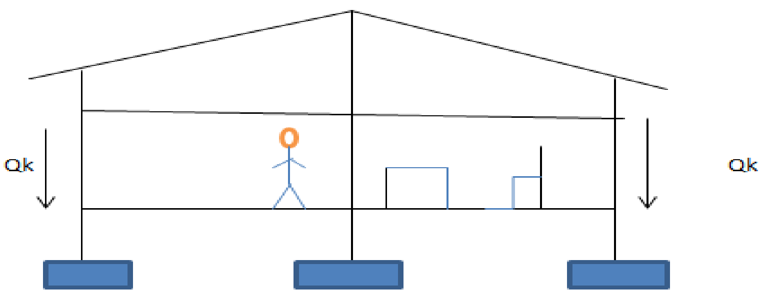


Figure2. 5. Live loads (Alden, 2011).

2.5.3. Wind loads

That is the force of the wind on structure. Its magnitude and impact on the structure depend on the location, shape and dimension of the building. Wind pressure can either add to other gravitational forces acting on the structure or, equally well, exert suction or negative pressure on the structure. Under particular situation, the latter may well lead to critical condition and must be considered in design. Some other characteristic loads are caused by earthquake (seismic loads) (MacGregor, 1997).

2.6. Loads combinations

Load combinations for the ultimate state various combinations of the characteristic values of dead load Gk, imposed Qk, wind load Wk and their partial factor of safety must be considered for the loading of the structure (Oxman, 2010).

Table2. 1. ***value of safety factor according to load combination*** *(Oxman, 2010).*

Load combination	Load type					
	Dead load		Imposed load		Earth and water	wind
	Advise	beneficial	Advise	Beneficial		
Dead and imposed (earth and water pressure)	1.4	1.0	1.6	0	1.4	-
Dead and wind(earth and water pressure)	1.4	1.0	-	-	1.4	1.4
Dead wind and imposed (earth and water pressure)	1.2	1.2	1.2	1.2	1.2	1.2

Various combination of the characteristic values of dead loads (Gk), imposed load (Qk), wind load (Wk) and their partial factor of safety must be considered for the loading of structure. There as follow:

1. Dead and imposed load: 1.4Gk+1.6Qk
2. Dead and wind load: 1.0Gk+1.4Wk
3. Dead imposed and wind loads: 1.2Gk+1.2Wk.

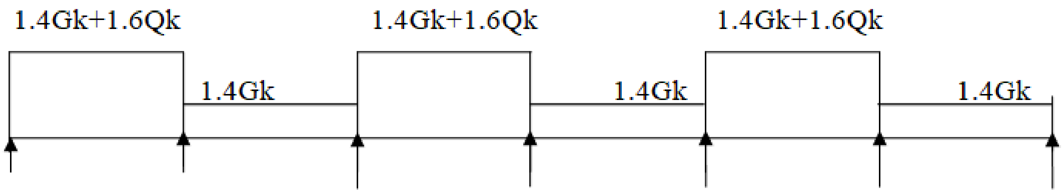


Figure2. 6. Load pattern when the maximum moment is in span

2.6.1. Limits state design

The design of an engineering structure must ensure that the under the worst loadings, the structure is safe, and during normal working condition the deformation of the members does not detract from the appearance, durability or performance of the structure. The limit state method involves applying partial factor of safety, both to the loads and to the material strength. The magnitude of the factor may be varied so that they may be used either with the plastic condition in the ultimate state or with more elastic stress range in working loads. The two principle types of limit state are the ultimate limit state and the serviceability limit state (Baker, 1956).

2.6.2. Ultimate limits state

This requires that the structure must be able to withstand, with an adequate factor of safety against collapse, the loads for which it is designed. The possibility of buckling or overturning must also be taken into account, as must the possibility of accidental damage as caused, for example, by an internal explosion (Kaprisin, 2011).

2.6.3. Serviceability limit state

This requires that the structural element do not exhibit any preliminary signs of failure. Generally, the most important serviceability limit state are: deflection (appearance or efficiency of any part of the structure must not be adversely affected by deflections), cracking (local damage due to cracking and spelling must not affect the appearance, efficiency or durability of the structure) and durability (in term of proposed life of the structure and its conditions of exposure) (Kaprisn, 2011)

Other limit state that may be reached include: excessive vibration, fatigue and fire resistance. The relative importance of each limit state will vary according to the nature of the structure.

The usual procedure is to decide which the crucial limits state of particular structure is, and base the design on this, although durability and fire resistance requirement may well influence the initial member sizing and concrete grade section. For the design of most reinforced concrete structure, it is usual to commence the design for the condition at ultimate limit state, which is then followed by checks to ensure that structure is adequate at the serviceability limit state (park, 1975).

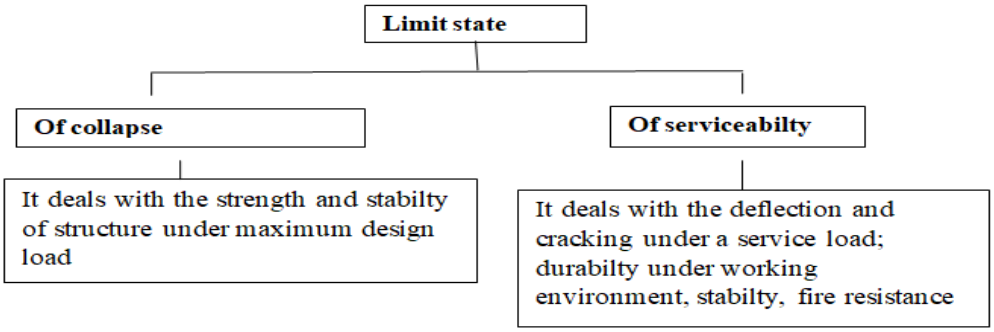


Figure2. 7. Limit states (Fiessler et al., 1979)

2.7. Component of the building

2.7.1. Foundation

The foundation is a structural unit that Uniform distributes the loads from the superstructure to the underlying soil. This is the first structural unit to be constructed for any building construction. A good foundation prevents settlement of the building (Driscoll, 1996).

2.7.2. Footing

Is structural members used to support columns, walls, and transmit their loads to the underlying soils. Reinforced concrete is a material admirably suited for footings and is used structures as such for both reinforced concrete 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. It is necessary to spread these loads over sufficient soil areas to permit the soil to support the loads safely. Not only is it desired to transfer the superstructure loads to the soil beneath in a manner that will prevent excessive or uneven settlements and rotations, but also it is also necessary to provide sufficient resistance to sliding and overturning (Driscoll, 1996).

2.7.3. Plinth beam

Plinth beam is a beam structure constructed either at or above the ground level to take up the load of the wall coming over it. Is a reinforced concrete beam constructed between the wall and its foundation? It is provided to prevent the extension or propagation of cracks from the foundation into the wall above when the foundation suffers from settlement. The minimum depth of plinth beam is 20cm where its with should match the width of final course of the foundation (Whitney & Benjamin, 1901).

2.7.4. Columns

Column is a structural element that transmits, through compression, the weight of the structure above to other structural elements below. In other words, a column is a compression member, although it may also resist to the bending forces due to continuity of the structure (Chisholm, 1911).

2.5.5. Beams

Beam is structural elements that transfer loads imposed along their length to their end points where the loads are transferred to walls, columns, foundations, and so on. Its mode of deflection is primarily by bending. The loads applied to the beam result in reaction forces at the beam's support points. The total effect of all forces acting on the beam is to produce shear forces and bending moments within the beam, that in turn induce internal stresses, strains and deflections of the beam. Beams are characterized by their manner of support, profile (shape of cross-section), equilibrium conditions, length, and their material (Arya, 2009).

2.5.6. Slab

A concrete slab is a common structural element of modern buildings, consisting of a flat, horizontal surface made of cast concrete. Concrete slab which is typically between 100 and 500 mm thick, are most often used to construct floors and ceilings, while thinner mud slabs may be used for exterior paving. In many domestic and industrial buildings, a thick concrete slab supported on foundations or directly on the subsoil, is used to construct the ground floor. These slabs are generally classified as ground-bearing or suspended. A slab is ground-bearing if it rests directly on the foundation, otherwise the slab is suspended (Garber, 2006).

2.7.7. Stairs

Stairs can be defined as set of steps leading from one floor of a building to another, typically inside the building; stairs should be designs so that they are convenient for the majority of people to use it, and because of the very young and old people may find difficult to use them, that why you have to put handrails which should be supported by balustrades on the open sides of staircases to prevent accidents (Eastman, 2009).

2.7.8. Ramps

Ramps can be defined as a structural member provided with the purpose of overcoming changes in levels either on the inside of the building or outside of the building as an alternative instead of using stairs, or they can both be used on one structure. A ramp is the best way provided to be used by people with different disabilities who find it difficult to use stairs, and also ramps can help in lifting up and down different materials inside the building (Chrest, 2012).

2.7.9. Roof

A roof is the top covering of a building, including all materials and constructions necessary to support it on the walls of the building or on uprights; it provides protection against rain, snow, sunlight, extreme of temperature, and wind. So, a roof is a part of the building envelope. The characteristics of a roof are dependent upon the purpose of the building that it covers the available roofing materials and the local traditions of construction and wider concepts of architectural design and practice and may be governed by local or national legislation. Roof can be either flat or sloped based on the location and weather conditions or the purpose of the building (Harris, 2000).

2.7.10. Wall

A wall is a continuous, usually vertical structure thin in the proportion to its length and height build to provide shelter as an external wall or divide building into rooms or compartments as an internal wall, wall separate the spaces inside and outside a building. The function of an external wall is to provide shelter against wind, rain and the daily and seasonal variation of outside temperature normal to its location, for reasonable indoor comfort. The primary function of the wall is to enclose or divide spaces of the building to make it more functional or useful.

Wall separate the spaces Inside and outside building, wall provide privacy afford security and gives protection against heats, cold, sun and rain (Collins, 1993).

2.7.11. Doors and windows

A door is defined as an operable barrier secure in an opening left in a wall for providing access to the users of the structure. It consists of two parts namely frame and shutter. The main condition of doors in a building is to serve as a connecting link between the various internal parts, the numbers of doors in a room should be kept minimum due to the fact that more numbers of doors will cause obstruction and reduce the effective usable carpet area of the room, in the general a door should have such dimension as will allow the movements of the largest object likely to use the door (Phillips *et al*,. 2003).

2.8. Soil exploration

The stability of the foundation of a building, a bridge, an embankment or any other structure build on soil depends on the strength and compressibility characteristics of the subsoil. Therefore, the elements of soil exploration should at least provide the following: information to determine the type of foundation required such as a shallow or deep foundation; and necessary information with regards to the strength and compressibility characteristics of subsoil to allow the design consultant to make recommendations on the safe bearing pressure or pile load capacity (Hanna, 1980).

2.8.1. Bearing capacity

Bearing capacity is the power of foundation soil to hold the forces of superstructure without undergoing shear failure or excessive settlement. Foundation soil is that portion of ground which is subjected to additional stresses when a foundation and superstructure are constructed. The allowable bearing capacity (qa) is the maximum bearing stress that can be applied to the foundation such that it is safe against instability due to shear failure and the maximum tolerable settlement is not exceeded (Hanna, 1980).

2.9. Bill of quantity

Estimating is the technique of calculating or computing the various quantities and expected expenditure to be incurred on a particular work or project.

A cost estimate is a compilation of many elements, an approximation of the probable quantity and unit cost of each of the elements (Stewart, 1991).

2.9.1 Roles of estimating and costing

Estimates serve a number of different functions in the construction industry. In the early stages of a construction program, the owner needs an estimate of the probable cost of construction. This conceptual estimate has to be prepared from a minimum amount of information because it is required at a time when the project is often little more than a vague idea in the mind of the owner. Once the design of the project is underway, budget amounts can be established for the various elements of the project. When the design is completed, a final pre-bid estimate can be compiled to anticipate the contractor has bid price for work.

If this estimate is accurate, the obtained bid prices will be within the owner's budget for the project. Most contracts that transpire in the construction industry results from competing bids from contractors to supply goods and services to meet certain specification for a stipulated sum of money. Estimates are also required after works starts on the project. In the cost control programs, estimating is required to facilitate the control of expenditure of founds on a project (Venkataraman & Pinto, 2008).

2.9.2 Requirements for preparing an estimate

The following are the basic requirements used before preparing an estimate;

- Drawings like plans, elevations, sections, etc. (drawings must be clear and with complete dimensions).

- Detailed specifications about workmanship & properties of materials (detailed description of the various items of work laying down the quantities and qualities of materials, their proportions, and the method of preparation, workmanship and execution of the work).
- Standard schedule of rates of the current year. The cost estimator must research costs, compare costs, and use professional judgment to prepare a quality cost estimate.
- Project plan detailing the project function, purpose and characteristics including information relating to the gross floor area of prime building spaces, equipment, and building systems.
- Floor-to-floor heights and general information about the exterior building elevations and floor elevations and floor plan configuration project.

2.9.3 Types of estimates

1. Detailed estimate (project design): the preparation of detailed estimate consists of working out quantities of various items of work and then determines the cost of each item:

Details of measurements and calculation of quantities (details of measurements form):

Table2. 2. ***Detail of measurements form***

S/N	Description of item	Length (L)	Breadth (B)	Depth/height	Quantity	Explanation note

- Abstract of estimated cost (abstract of estimated form: S/N, description, quantity**, unity, rate, amount).**

Table2. 3. ***Abstract of estimate form***

S/N	Description of item	Quantity	Unity	Rate	Amount

2. Approximate estimate (Project planning): is prepared from the practical knowledge and cost of similar works. It is required for studies of various aspects of work of project and for its administrative approval. It can decide whether the net income earned justifies the amount invested or not.

Methods:

- Plinth area method.
- Cubical contents methods.

CHAPTER 3. METHODOLOGY

3.1 Introduction

This chapter describes in details the various research procedure and techniques used during the study, the sample elements description, the analysis methods, data creation techniques, and some calculation techniques that were used by the researcher during data processing and analysis. According to, a method is a set of intellectual operations which enables to analyze, to understand and to explain the analyzed reality. In this research, eachstep has its own method and techniques

3.2 Site description

This Fig.1 shows the site location which located in Gasabo district, Gisozi sector. The site where projected should be implemented had enough space needed, has access to water, has access to electricity and it has the road used by users.

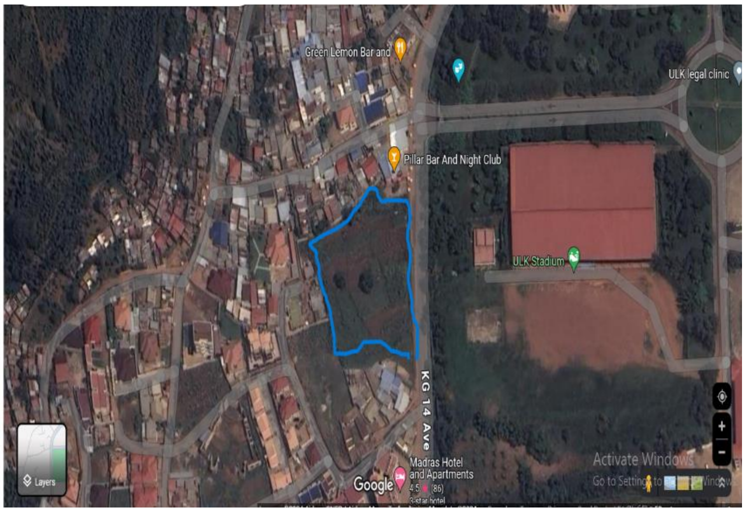


Figure3. 1. Location of the plot

3.3. The data collection method

3.3.1. Primary data collection

The methods used in this dissertation research were based primary data especially observation in order to know more information about it and also site observation in order to know enough information about the study area, to know also if the proposed area of construction is suitable to be constructed and if that area has facilities like water, roads, electricity.

3.3.2. Secondary data collection

The different methods that were used to fulfill all requirement of the project were reading books from library and also searching on the internet as known that the internet is the global serves where it is easy to get information or research for different knowledge including the design of building so internet was the most helper method to achieve this proposing design and also Microsoft word was used for writing.

The following methods will be used

- location of the site using Arc Gis
- Architectural design had been done by using CADs software (ARCHICAD, AUTOCAD)
- Structural design had been done by using Protostructure

3.2. Architectural design

Architectural drawing is a technical drawing of a building project that falls within the definition of architectural drawings are used by architects and of others for a number of purposes: to develop a design idea of a proposal, to communicate the idea concepts, to convince clients of merits of design, to enable a building to be constructed as a record of the completed work, and to make a record of a building that already exists. Architectural drawings were those drawings which satisfy the ideas, the procedures which was followed during this project were taking the information on the site, after taking information Archicad 23 has been used to produce architectural design of the project including particular floor plans, elevations, sections, roof plan, foundation plan, perspective and some elements of structure and its details.

3.2.1. The components of architectural drawings

Conceptual design is a function of choosing a suitable from system or arrangement to meet a given architectural appearance some of architectural element are: site plan, floor plans elevations, sections, roofs plan, foundation plan perspective and some elements of structure and it details .this chapter all architectural elements are designed with ARCHICAD 24, TWIN MOTION.

3.3 Structure design

The structural design is an art and science of understanding the behavior of structural members subjected to load and designing them with economy and elegance to give a safe, serviceable and durable structure.

3.3.1. Structure design information

1. The concrete that would be used must be of high compressive strength at 28 days of age. The specific weight of concrete including reinforcement was $25KN/m^3$. The concrete to be used would have a resistance (fc) of 30 N/mm2 for all elements of structure except slab, which would have fc of $25N/mm^2$.

2. The reinforcements to be used would be hot-lolled reinforcement having resistance strength (fy) of 460N/mm2 for main bars and mild steel for shear reinforcement (fvy) would be having characteristic strength of $250N/mm^2$.

3. Geotechnical study was not conducted due to limited access to the equipment and taking account time constraints. Based on secondary source of data, the bearing capacity of soil in Kigali found to be 300 N/m^2.

4. Indians standard (IS), ACI 318-08 and British standard (BS) code of practice were used in this project. BS-8110 used on geotechnical parameters considerations, ACI 318-08 was used while designing shear wall and IS456-2000 was used in analyzing and designing by using ROBOT structural analysis and designing software. Therefore, the result presented includes work done with help of IS456-2000 codes of practice.

3.3.2. Structural design of slab

The thickness of the slab lies between $\frac{lx}{20}$ and $\frac{lx}{40}$ where Lx is the shorter side of the panel using the biggest panel among them.

The effective height (ho) = the thickness of the slab (hf)-the concrete cover

3.3.2. 1. Load on slab

- Self-weight = safety factor (1.4) *thickness of slab*1m*1m*unit weight of reinforced concrete.
- Finishes = safety factor (1.4) * thickness of finishes.
- Live load= safety factor (1.6)* weight of apartment for general use.

3.3.2. 2.Type of slab

- $\Lambda = \frac{Ly}{Lx}$ To check whether slab is one-way or two-way slab.

❖ Where λ = ratio of long side $\frac{Ly}{Lx}$ ratio of short side

3.3.2. 3.Bending moment

❖ $Mx=\alpha sx * P * lx^2$

❖ $My = \alpha sy * P * lx^2$

❖ Where: Mx = moment at the long side, My = moment at the shorter side,

❖ Asx, αsy = coefficient related to the design of slabs, P = total load on the slab, lx = short side of slab.

3.3.2. 4.Required steel reinforcement

$\alpha m=\frac{Mmax}{Rb*b*ho^2}$

Where αm: coefficients related to the design of members subjected to bending moment, Rb: design concrete compressive strength, b: width of the compression area, ho: effective height, Mmax: maximum bending moment.

$As = \frac{Mmax}{\eta*Rs*ho}$

Where As: total cross section of steel reinforcement, Rs: design steel tensile stress, ho: effective height, η: coefficient related to the design of members subjected to bending moment.

3.3.3. Structural design of beam

Computation of the depth of the beam

$\frac{lmax}{15}$ to $\frac{lmax}{8}$

Where lmax: is the largest span between two consecutive beams.

Computation of web flange of beam (bw)

$0.5 \leq \frac{bw}{h} \leq 1$

Where bw: is the web of flange of the beam, h: is the height of the beam.

3.3.3.1. Computation of the width of beam (bf)

$$bf \leq \begin{cases} \text{1/3 of the beam span} \\ \text{half of the distance between beams} \\ 12*hf + b \end{cases}$$

3.3.3. 2. Load on beam

Self-weight= safety factor*breadth of the web*total height of the beam*1m*unit-weight of reinforced concrete.

Cement plaster on the beam= safety factor*thickness of plaster*both two sides of the beam*unit weight of concrete.

Permanent load from the slab= (self-weight of the slab + finishes of the slab) *weight of apartment for general use.

Masonry wall= safety factor*thickness of the wall*height of the wall*1m*unit weight of brick masonry.

Plaster on the wall= self-weight*thickness of the plaster* height of the wall * 1m * unit weight of concrete * 2 (two sides of wall).

Live load from the slab= live load of the slab *weight of apartment for general use

3.3.3.3. Bending moment

$Mmax = (\alpha G + \beta Q) * L^2$

$Vmax = (\alpha G + bQ) * L$

3.3.3.4. Required steel reinforcement

$\alpha m = \frac{Mmax}{Rb.ho^2.b}$

Whereαm: coefficients related to the design of members subjected to bending moment, Rb: design concrete compression strength, b: the width of the compression area, ho: effective height, Mmax: maximum bending moment.

$As = \frac{Mmax}{\eta.Rs.ho}$

Where As: total cross section of steel reinforcement, Rs: design steel tensile stress, ho: effective height, η: coefficient related to the design of members subjected to bending moment

3.3.3.5. Design for shear renforcement

$qsw = \frac{Vmax^2}{4*\psi bt*Rbt*b*ho^2}$

We choose $\phi 8 = Asw = 0.503 cm^2$ most time and Rsw=80% of Rs

Stirrups spacing: $S = \frac{Rsw*Asw*n}{qsw}$

$$S \leq \begin{cases} Smax = \frac{0.75\psi bt*Rbt*b*ho^2}{Vmax} \\ \text{The breadth of the web} \\ 30 \text{ cm} \end{cases}$$

3.3.4. Structural design of column

3.3.4. 1. Load on column

Column loading area= considering column tributary area

Slab permanent load= (self-weight of the slab + finishes of the slab)*area of column.

Slab live loads= live load of the slab * area of column.

Wall & plaster= (Masonry wall + plaster on the wall) *area of column.

Beams= self-weight of the beam*area of the column.

Column= safety factor (1.4) *column cross section area*height of storey * unit weight of reinforced concrete.

3.3.4. 2.Required steel reinforcements

As $=\frac{\frac{N}{\psi}-Rb*Ab}{Rsc}$

Where, As: total cross section of steel reinforcement, N: total load on the floor, Rb: design concrete compression strength, Ab: the area of the column cross section, Rsc: area of steel compressive strength, ψ: coefficient used to take into account the column slenderness and the construction inaccuracies.

$\lambda = \frac{lo}{a}$, lo=0.7H for interior column

lo = 0.9H for edge column

Where, λ is the slenderness ratio, lo is the effective height, H is effective height of the column, a: is the smaller side of the column cross section.

When As < 0, the concrete alone can carry the applied shear loads but practically we have to provide the minimum amount of steel reinforcements 0.4 % of Ab so, in this case the same steel reinforcements will be arranged in the upper floors.

3.3.5. Structural design of pad foundation

Soil bearing capacity (Ps): This soil bearing capacity is given by the results of lab technician Af: total loads on the soil / design bearing capacity. Where Af: area of foundation

3.3.5. 1.Design pressure

P: $\frac{Nc}{Af}$

Where p: design pressure, Nc: Load on the column

3.3.5. 2.Checking the punching shear

Qf = Nf - Δq ≤ Rbt * Ab

Where Qf: punching shear, N: load transmitted by the column to the foundation,

Ab= um*ho

Where, um: is the average perimeter

Um= 2(ac + bc + 2ho)

Where ac: width of the column, bc: length of the column,

Δq = P(ac + 2ho) * (bc + 2ho)

3.3.5. 3. Moment calculation

Mbf = Maf $\frac{1}{2}$ Paf * $(\frac{bf-bc}{2})^2$

Where Mbf: Maximum moment, P: design pressure, af: width of the foundation, bf: length of the foundation, bc: length of the column.

3.3.5. 4.Required steel reinforcements

As = $\frac{M}{0.9*Rs*ho}$

Where M: is the maximum moment, ho: effective height of the foundation, Rs: design steel tensile stress.

3.3.6. Structural design of stair

The thickness of the equivalent horizontal slab:

hl = $\frac{dl}{\cos(\alpha)} + \frac{Riser}{2}$

3.3.6. 1.Loads on the stair

Self-weight= safety factor (1.4) * thickness of the equivalent horizontal slab * 1m * 1m * unit weight of reinforced concrete.

Finishes= safety factor * thickness of finishes.

Live load= safety factor (1.6) * weight of apartment for general use.

3.3.6. 3. Steel reinforcement in the stair

αm = $\frac{Mmax}{Rb.ho^2.b}$

Where αm: coefficients related to the design of members subjected to bending moment, Rb: design concrete compression strength, b: the width of the compressive area, ho: effective height, m can be positive or negative if m is positive means that the moment should be at the bottom, and if m is negative here the moment should be at the top.

As = $\frac{Mmax}{\eta*Rs*ho}$

Where As: total cross section of steel reinforcement, Rs: design steel tensile stress, ho: effective height, η: coefficient related to the design of members subjected to bending moment.

3.3.7. Structural design of ramp

Dl is between ($\frac{h}{20}$ and $\frac{h}{30}$)

Where, h: is the height of column, Dl: waist,

he: $\frac{dl}{\cos\alpha}$

Where he: equivalent height,

ho: he – concrete clear cover where ho: effective height.

3.3.7.1. Load on the ramp

Self-weight = safety factor (1.4) * thickness of slab * 1m *1m * self-weight of reinforced

Finishes = safety factor (1.4) * 1.5

Live load + safety factor (1.6) * weight of apartment buildings

3.3.7.2. Calculation of steel reinforcement in the ramp

$\alpha m = \frac{Mmax}{Rb.ho^2.b}$

Whereαm: coefficients related to the design of members subjected to bending moment, Rb: design concrete compression strength, b: the width of the compressive area, ho: effective height, m can be positive or negative if m is positive means that the moment should be at the bottom and if m is negative here moment should be at the top.

$As = \frac{Mmax}{\eta * Rs * ho}$

Where As: total cross section of steel reinforcement, Rs: design steel tensile stress, ho: effective height,η: coefficient related to the design of members subjected to bending moment.

3.4. Cost estimation

Estimating is the technique of calculating or computing the various quantities and expected expenditure to be incurred on a particular work or project. The quantity like earthwork, foundation concrete, brickwork, can be workout by long wall-short wall method: in this method, the wall along the length of room is considered to be long wall while the wall perpendicular to long wall is said to be short wall. To get the length of long wall or short wall, calculate first the centerline lengths of individual walls. Then the length of long wall, (out to out) may be Calculated after adding half breadth at each end to its centerline length. Thus the length of short wall measured into in and may be found by deducting half breadth from its centerline length at each end. These lengths are multiplied by breadth and depth to get quantities.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Introduction

This chapter presents the results of this research project. It shows and discusses the results of the architectural design, structural design and the cost estimation of the proposed Public Library building in Kigali.

4.2. Architectural design

Architectural design of the Public Library Building was done using ArchiCAD 23. This building is G+3 building with an area of 852 m^2 the conceptualization of this building was done by taking consideration the Library room standard sizes, the architectural shape and size of Library was dependent on different factors including adequate light, proper air circulation, controlled sound level, right and working and living condition. Surface and storage for stationary, equipment and other Library tools and machines was considered. In architectural design also the view of building is considered, therefore the building shuttered with glass found as one presenting pleasant appearance.

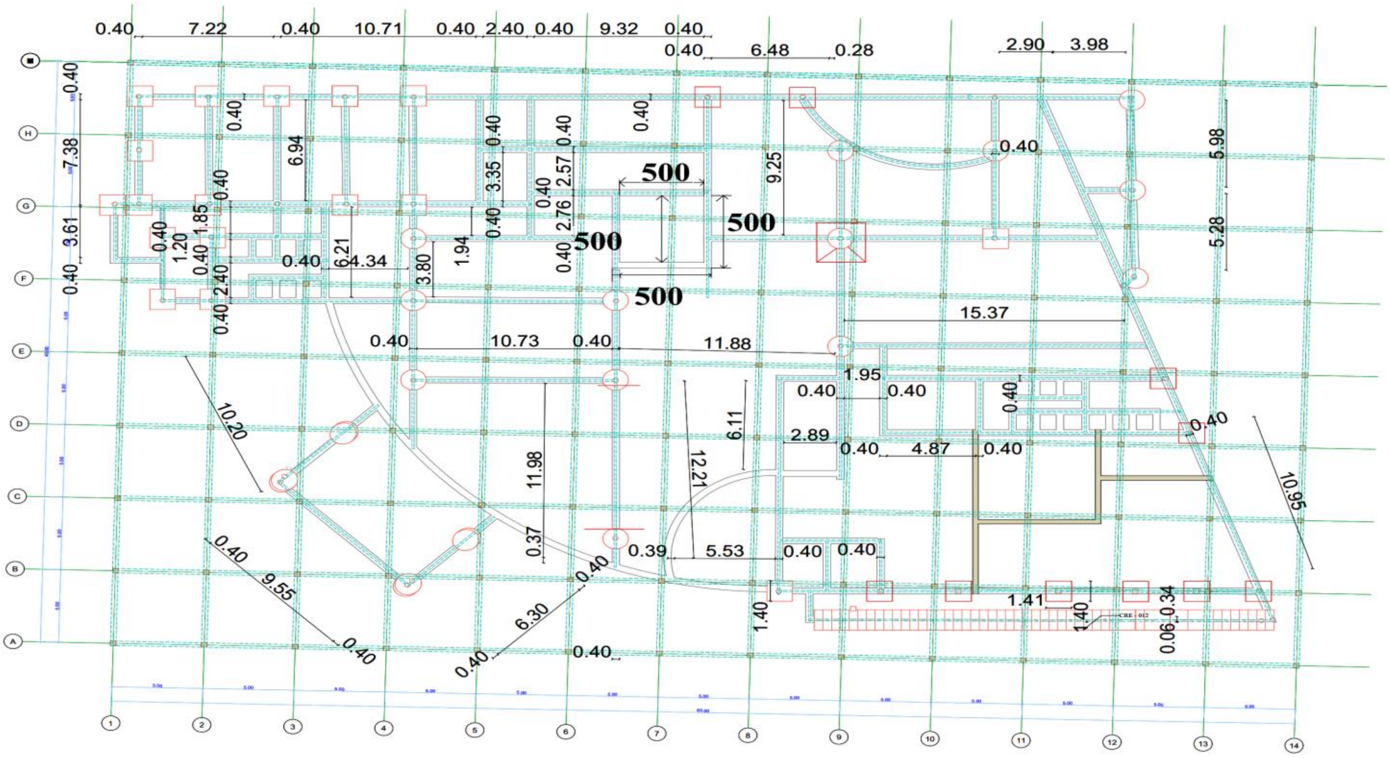


Figure4. 1. ***Structural plan***

4.3. Design of interior slab panels (p27)

Slab is a horizontal plate element carrying vertical distributed loads over its surface. The thickness of the slab to be used is based on the deflection control

Figure4. 2. ***Structural plan shows critical panel***

Calculation Depth of Slab

The thickness of the slab lies between Lx/20 and Lx/40

Where:Lx is the shorter side of the panel

$$hf = \frac{500}{40} = 12.5\text{cm and hf} = \frac{500}{25} = 20\text{cm}$$

we are going to take the slab thickness (hf)=16cm

The effective height (ho)= hf – clear cover=16-2.5= 13.5cm

Calculation of dead load

Slab self –weight = 1.4*1*1 *0.16*24KN/m = 5.376KN/m^2.

finishes =1.4*1*1*1.5=2.1KN/m^2

Total dead load (G) = (5.376+2.1)KN/m^2=7.476KN/m^2

Calculation of live load

Unit weight of Public Library Building is 2KN/m^2

Live load (Q) = 1.6*2KN/m^2=3.2 KN/m^2

Total load on slab is given by:

P= G+Q =7.476 KN/m²+3.2KN/m² = 10.676KN/m²

Design of interior biggest pannel

Ly/Lx >2: One-way slab

Ly/Lx ≤ 2: Two-way slab

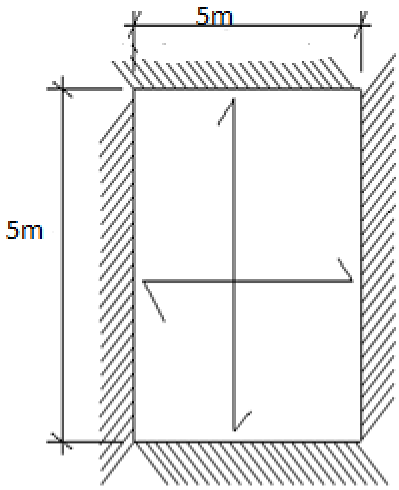


Figure4. 3. ***Panel (p37)***

Ly=5.m

Lx=5m

$$\text{Slenderness}(\lambda) = \frac{Ly}{Lx}$$

$$= \frac{500}{500} = 1<2(\text{two way slab})\text{required designed steel reinforcement in both direction}$$

Bending moment

Mx=αsx*p*Lx2

My=αsy*p*Lx2

α^{-}sx=0.042

α^{+}sx=0.018

α^{-}sy=0.042

$\alpha^{+}sy$=0.018

Mx^{-} =0.042*10.676*5^2=11.209KNm

Mx^{+}= 0.018*10.676*5^2=4.804KNm

My^{-}= 0.042*10.676*5^2=11.209KNm

My^{+}= 0.018*10.34*5^2=4.804KNm

Steel bars calculation

For concrete C25

$M^{-}max$=11.209 KNm

$M^{+}max$=4.804 KNm

Rb= 1.4 KN/cm2

Rs= 40 KN/cm2

Required Steel reinforcements at the top

$$\alpha m = \frac{M^{-}}{Rb * ho^2 * b} = \frac{11.209 * 100}{1.4 * 13.5^2 * 100} = 0.0439$$

Using table from appendix the correspond value of αm

ξ= 0.05; <ξR=0.559

η= 0.975

$$As = \frac{M^{-}}{\eta * ho * RS} = \frac{11.209 * 100}{0.975 * 13.5 * 40} = 2.128 cm^2/m$$

Let’s take 5φ10/m with the required As = 3.93cm^2/m

Required steel reinforcements at the bottom

$$\alpha m = \frac{M^{+}}{Rb * ho^2 * b} = \frac{6.138 * 100}{1.4 * 13.5^2 * 100} = 0.025$$

ξ= 0.03; <ξR=0.559

η=0.985

$$As = \frac{M^{+}}{\eta * ho * RS} = \frac{6.138 * 100}{0.985 * 12.5 * 40} = 1.24 cm^2/m$$

Since As is less than the minimum allowable, let's take 5φ10/m

with the required As = 3.93cm^2/m

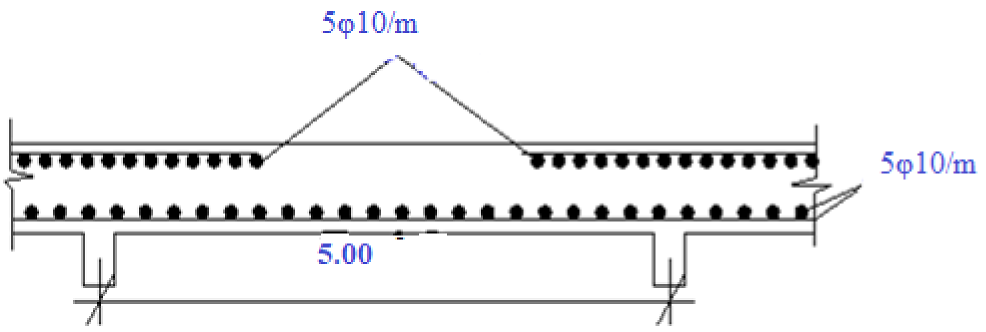


Figure4. 4. ***Slab detail***

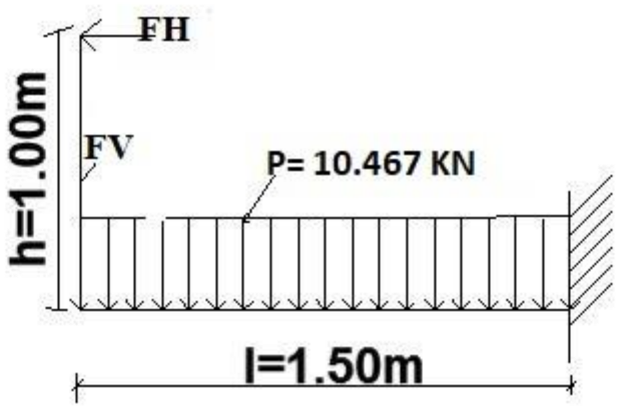


Figure4. 5. ***Cantilever slab***

FH =Horizontal live load

FV=weight of the protection bars

Load calculation

P=10.476KN/m

FH=1.6*0.5=0.8KN/m

FV=1.4*1KN=1.4KN/m

Bending moment

$$M^{-}max = \frac{Pl^2}{2} + FH * h * FV * l$$

$$M^{-}max = \frac{10.476 * (1.5)^2}{2} + (0.8 * 1.5 * 1.4 * 1) = 13.46KNm$$

Steel bars calculation

For concrete C25

$\xi R=0.559$

Rb=1.4KN/cm2

Rs=40KN/cm2

$$\alpha m = \frac{M^{-}}{Rb * ho^2 * b} = \frac{13.46 * 100}{1.4 * 13.5^2 * 100} = 0.065$$

ξ= 0.07; <ξR=0.393 (Case of singly reinforcements)

Using table the value

η= 0.940

$$As = \frac{M^{-}}{\eta * ho * RS} = \frac{13.31 * 100}{0.965 * 13.5 * 40} = 2.75cm^2/m$$

Since As is less than the minimum allowable, let's take5ϕ10/m

with the required As = 3.93cm^2

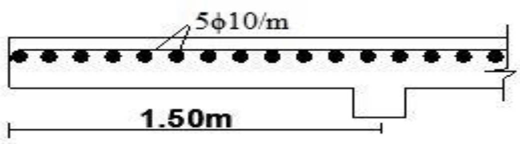


Figure4. 6. ***Steel arrangement in cantilever slab***

4.4. Design of longitudinal beam

A beam in engineering is rigid member or structure supported at each end, subject to bending stress from a direction perpendicular to its length. A beam is structural element that is capable of withstanding load primarily by resisting bending.

The loads that are acting on those beams are from: the own weight of the beam, the load transmitted to the beam from slab and the wall loads. Beams are supported by the columns and hence transfer the loads from the slabs via the columns to the foundation and the foundation to the ground.

Beam sizes computation

a) Calculation for the overall depth of the beam (h)

The overall depth of the beam lies within the following interval.

$\frac{Lmax}{12} \leq h \leq \frac{Lmax}{8}$, **Where**

L_{max} is the largest span between two Consecutive beams

For this beam L_{max} is equal to 500cm which will give $\frac{500}{12} \leq h \leq \frac{500}{8}$

$\Rightarrow$ **41.66cm$\leq$ h $\leq$ 65cm**

Let's take h =50cm

b) Calculation for the breath of the beam

$\frac{h}{3} \leq b \leq \frac{h}{2}$ For this beam the breath is ranging in the interval of $\frac{\mathbf{50}}{\mathbf{3}} \leq \mathbf{b} \leq \frac{\mathbf{50}}{\mathbf{2}}$ which is **from 16.666cm to 25cm.**

In line with the above assumption, **let's take b = 25cm**

c) Calculation for the breath of the flange (b_f)

b_f =is equal to the lesser or smallest of:

a) 12hf +b=12*15cm+25cm = 205cm

b)A third of the beam span $= \frac{500}{3} = 166.66$cm

C)The half of the distance between beams $= \frac{250}{2} = 125$cm

The b_f of the beam equal to 125cm

Load calculation for the beam

Self –weight of the beam= 1.4*0.25*0.5*1*24=4.2KN/m

Cement plaster on the beam = 1.4*0.03*0.66*20=0.5544 KN/m

Permanent load from the slab= 7.676*3.5=26.866 KN/m

Live load from the slab= 3.2*3.5=11.2 KN/m

Masonry wall= 1.4*0.2*2.9*1*18=14.61 KN/m

Plaster on the wall= 1.4*0.03*2.9*2**1*20=4.872 KN/m

Table4. 1. Load cases used in software in analysis of beam

Case	Label	Case name	Nature	Analysis type
1	DL1	DEAD	Structural	Static - Linear
2	DL2	LIVE	Category A	Static - Linear
3		1.4 DEAD + 1.6 LIVE	Structural	Linear Combination
4		DEAD + LIVE	Structural	Linear Combination

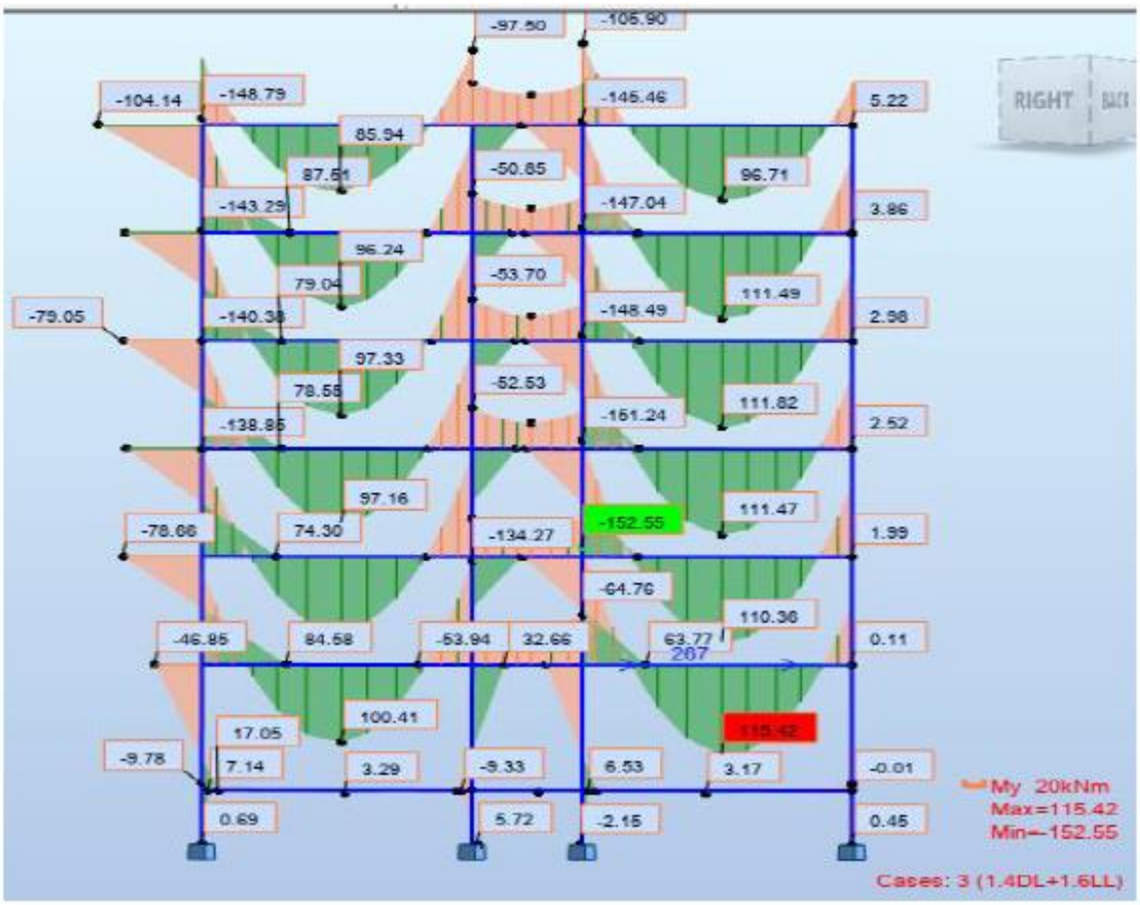


Figure4. 7. ***Bending moment diagram***

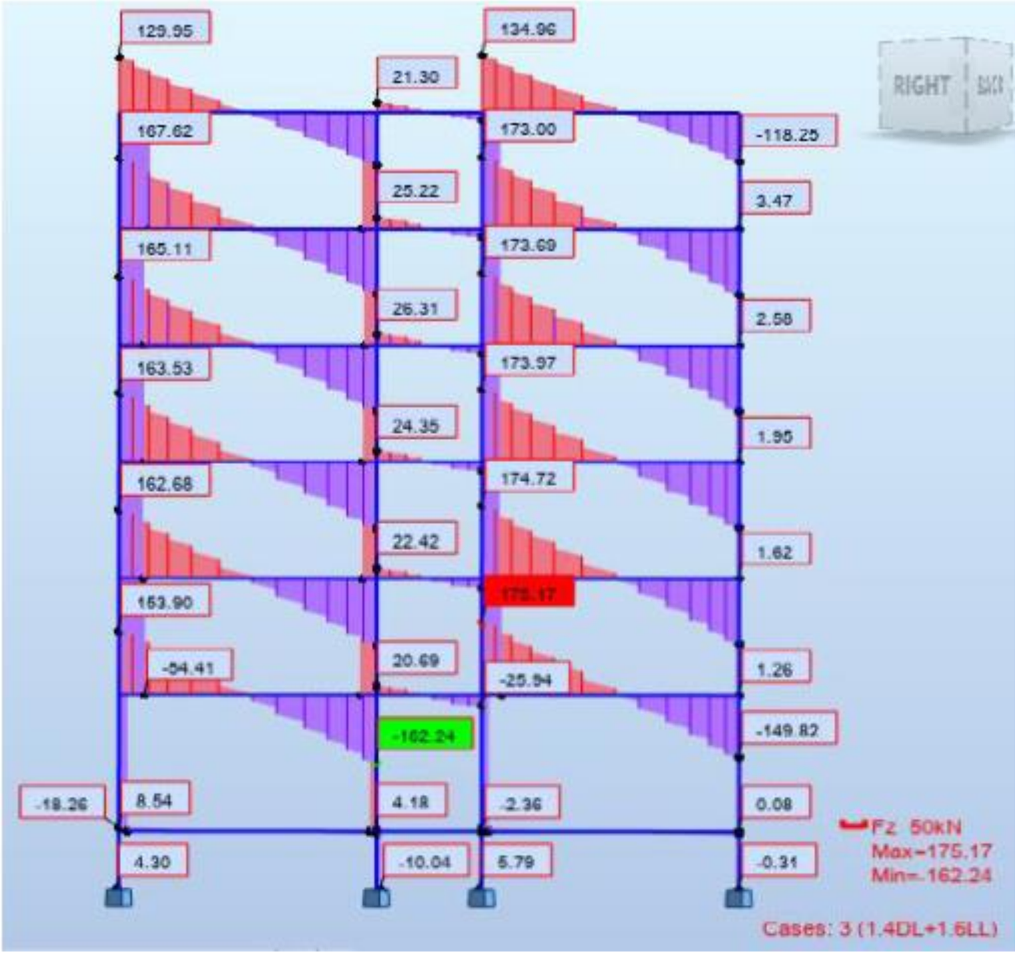


Figure4. 8. ***Shear force diagram of frame***

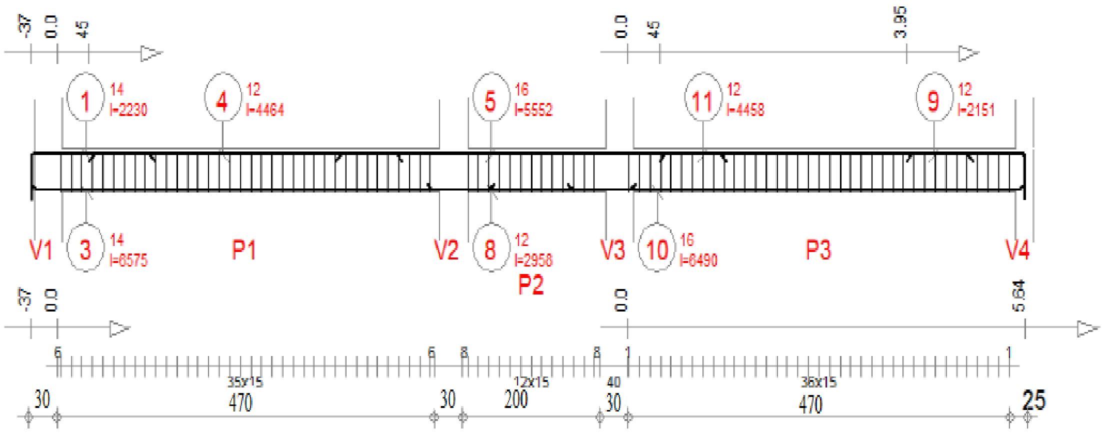
The design calculation options and results for the critical beam are shown in Table below The calculations were done according to BS 8110.

Table4. 2. Design calculation options and results for the critical beam

Material properties	Concrete C25, fck = 25 MPa Steel reinforcements, fy = 460 MPa					
2. Internal forces at ULS	Span No.	Bending moments (kN.m)			Shear forces (kN)	
		Left Support	Mid-Span	Right Support	Left support	Right support
	1	-93.86	99.89	-104.62	145.23	-152.83
	2	-54.21	-48.98	-59.69	19.72	-24.96
	3	-120.41	113.47	-65.13	165.41	-143.78

	Span No.	Bending moments (kN.m)			Shear forces (kN)	
		Left Support	Mid-Span	Right Support	Left support	Right support
	1	-64.73	68.65	-71.79	100.24	-105.30
	2	-37.26	-33.66	-40.97	13.57	-17.09
	3	-82.83	77.97	-44.84	114.05	-99.17
Required reinforcements	Span No.	Near Supports			Mid-span	
		Top	Bottom		Top	Bottom
	1	4T14	4T14		2T12	4T16
	2	4T16	2T12		4T16	4T16
	3	4T16	4T16		2T12	4T16
Deflection and cracking	Span No	Deflection (mm)			Cracking width (mm)	
		total	Allowable			
	1	12	23		0.3	
	2	0	9		0.1	
	3	13	23		0.3	

The arrangement of reinforcements in the critical beam as detailed by the software is shown on Fig. 19



Pos.	Reinforcement	Code	Shape	Number	Pos.	Reinforcement	Code	Shape	Number	Pos.	Reinforcement	Code	Shape	Number
1	14 l=2230	00	1770	4	4	12 l=4464	00	4460	2	8	12 l=2958	00	2960	2
2	8 l=1261	31	180 / 60	36	5	16 l=5552	00	5550	4	9	12 l=2151	00	1690	4
3	14 l=6575	00	6580	4	7	8 l=1284	31	180 / 60	50	10	16 l=6490	00	6490	4

Figure4. 9. ***Steel reinforcement diagram in software***

Material survey:

- Concrete volume = 3.85 (m3)
- Formwork = 46.81 (m2)

- Steel T
  - Total weight = 3.21 (kN)
  - Density = 0.83 (kN/m3)
  - Average diameter = 10.7 (mm)
  - Survey according to diameters:

Table4. 3. Material survey

Diameter	Length(m)	Weight(KN)
8	152.48	0.59
10	62.64	0.38
12	165.29	1.44
14	41.10	0.49
16	20.43	0.32

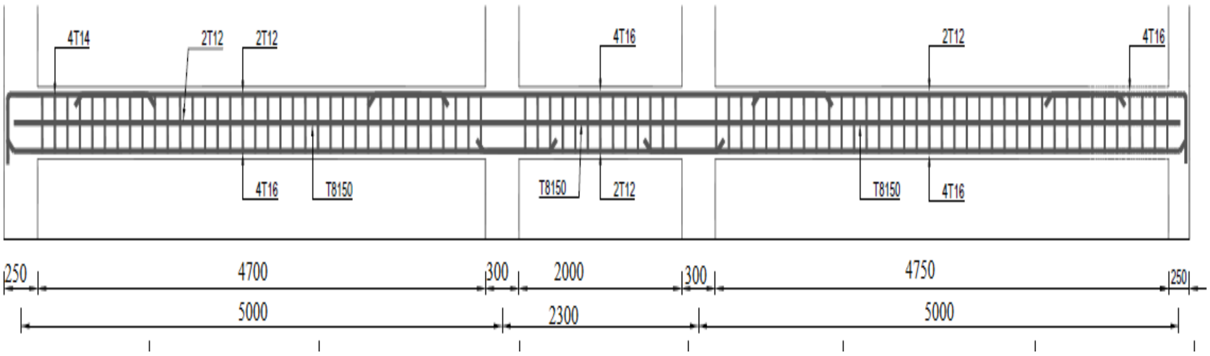


Figure4. 10. ***Critical beam in detailed***

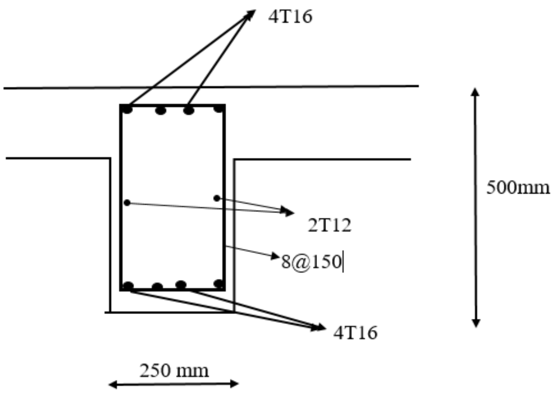


Figure4. 11. Section near the span

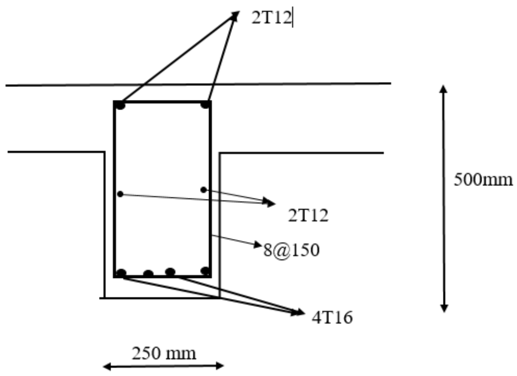


Figure4. 12. Section at mid span

4.5. Design of interior critical column

Column is the vertical structure member which carries the compressive loads from the beam and slabs down to the foundations. The column designed is the one loaded more than others and done by analytical method, the below calculations show how the column is calculated

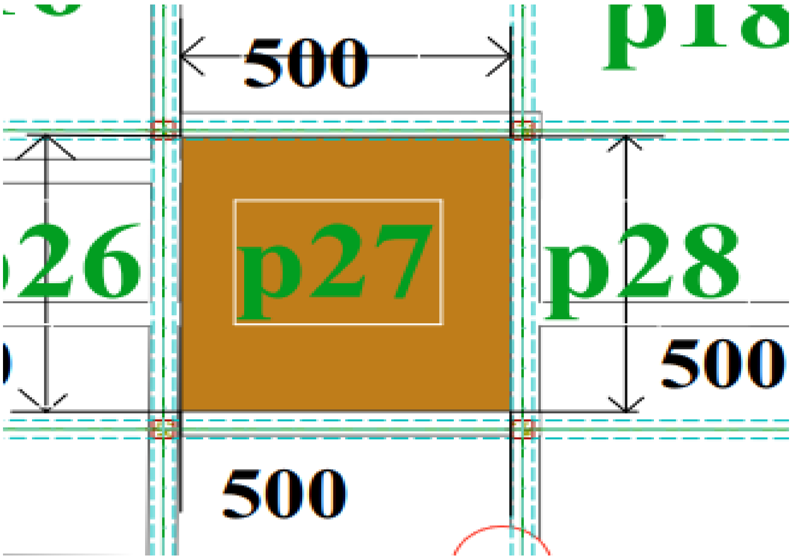


Figure4. 13. ***Critical internal column***

4.6. Calculation of dead load

Column cross section: 30cm*25cm=750cm^2

The height of the wall masonry =3m-0.500m=2.50m

The height of the area of the plaster=3m-0.16m=2.84m

Self-weight load of column= (1.4*0.25*0.30*3*24)KN=7.56KN/m

Permanent Load from the slab = (7.676*4.85*5.00) KN =186.143 KN

Live load from slab= 3.2*4.85*5=77.6 KN

Load from the beam =1.4*0.40*0.25*(4.85+5.00)*24KN=41.37KN

Load from the Plaster=1.4*0.03*2.84*(4.85+5)*2*20KN=46.7KN

Load of Masonry wall =1.4*0.20*2.55*(4.85 +5)*19KN=133.62KN

Loads from the roof =186.143/2=93.03 KN

Ground floor part of the column

Ground column self-weight=1.4*0.25*0.30*3.5*24=8.82 KN

N1= (186.143+77.6 +133.62+41.37+46.7)*3+ (7.56*3) +93.03+8.82 =1567.719 KN

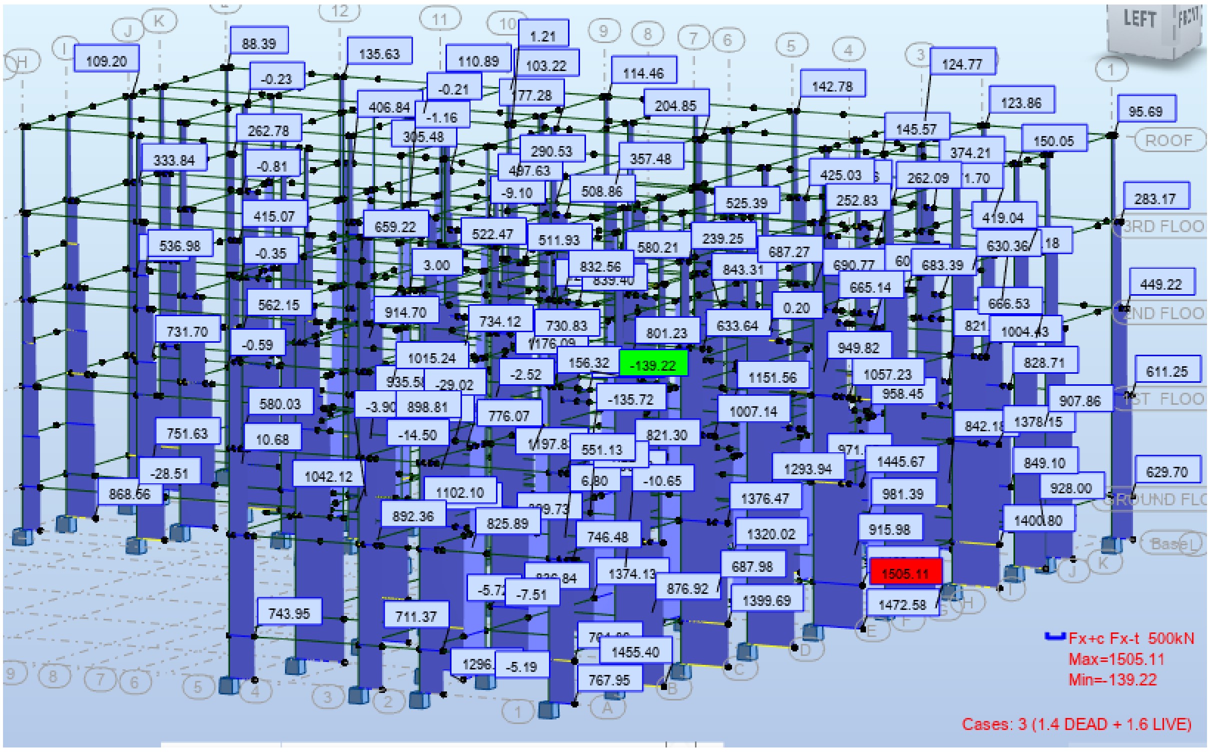


Figure4. 14. ***Ground floor part of the column***

Slender ratio

$$\lambda = \frac{0.7h}{a} = \frac{0.7 * 350}{25} = 9.8 \leq 14(\text{no slender, column is short})$$

Table4. 4. Slender ratio

λ	6	8	10	12	14	16	18	20
Φ	0.92	0.91	0.89	0.86	0.82	0.77	0.71	0.64

From the table φ is 0.89

Required steel reinforcement on ground floor part of the column

$$As = \frac{\frac{N}{\varphi} - Rb * Ab}{Rs} = \frac{\frac{1567.79}{0.89} - 1.3 * 25 * 30}{40} = 19.66cm^2$$

Let as take 6Φ22 with As=22.18cm^2

The percentage of the As with respect to column cross section must lie between 0.4% and 4%

In this case we have [(22.18*100)/750] %=3%   the steel reinforcement are (OK)

1stfloor part

N2= (186.143+77.6 +133.62+41.37+46.7)*2+ (7.56*3)+93.03+=1086.75 KN

Slender ratio

$$\boldsymbol{\lambda} = \frac{0.7h}{a} = \frac{0.7 * 300}{25} = 8.4 \leq 14(\text{no slender, column is short})$$

Table4. 5. Slender ratio

λ	6	8	10	12	14	16	18	20
Φ	0.92	0.91	0.89	0.86	0.82	0.77	0.71	0.64

From the table φ is 0.91

Required steel reinforcement on ground floor part of the column

$$As = \frac{\frac{N}{\varphi} - Rb * Ab}{Rs} = \frac{\frac{1086.75}{0.89} - 1.3 * 25 * 30}{40} = 6.15cm^2$$

Let as take 6Φ12 with As =6.79cm^2

The percentage of the As with respect to column cross section must lie between 0.4% and 4%

In this case we have [(6.15*100)/750] %=0.82%   the steel reinforcement are (OK)

2nd floor part

N3= (186.143+77.6 +133.62+41.37+46.7) + (7.56*2) +93.03= 593.58KN

$$As = \frac{\frac{N}{\varphi} - Rb * Ab}{Rs} = \frac{\frac{593.58}{0.89} - 1.3 * 25 * 30}{40} = -7.70cm^2$$

Let as take 4Φ12withAs=4.52cm^2

For the second floor, The negative sign means that only the concrete is able to support the load, however we cannot make a plain concrete column without steel bars, therefore let's use As of 4.52cm^2 The percentage of the As with respect to column cross section must lie between 0.4% and 4% In this case we have [(4.52*100)/750] %=0.60% (OK)

3rd floor part

N4= 7.56* +93.03+77.6+41.37 = 219.56KN

$$As = \frac{\frac{N}{\varphi} - Rb * Ab}{Rs} = \frac{\frac{219.56}{0.89} - 1.3 * 25 * 30}{40} = -18.20cm^2$$

Let as take 4Φ12withAs=4.52cm^2

For the second floor, The negative sign means that only the concrete is able to support the load, however we cannot make a plain concrete column without steel bars, therefore let's use As of 4.52cm^2 The percentage of the As with respect to column cross section must lie between 0.4% and 4% In this case we have [(4.52*100)/750] %=0.60% (OK)

Links:

Minimum size =1/4 size of the largest compression bar but not less than 6 mm of diameter

Maximum spacing should not exceed the lesser of 12 size of the smallest compression bar or the least lateral dimension of the column

Let's take ϕ6@200mm

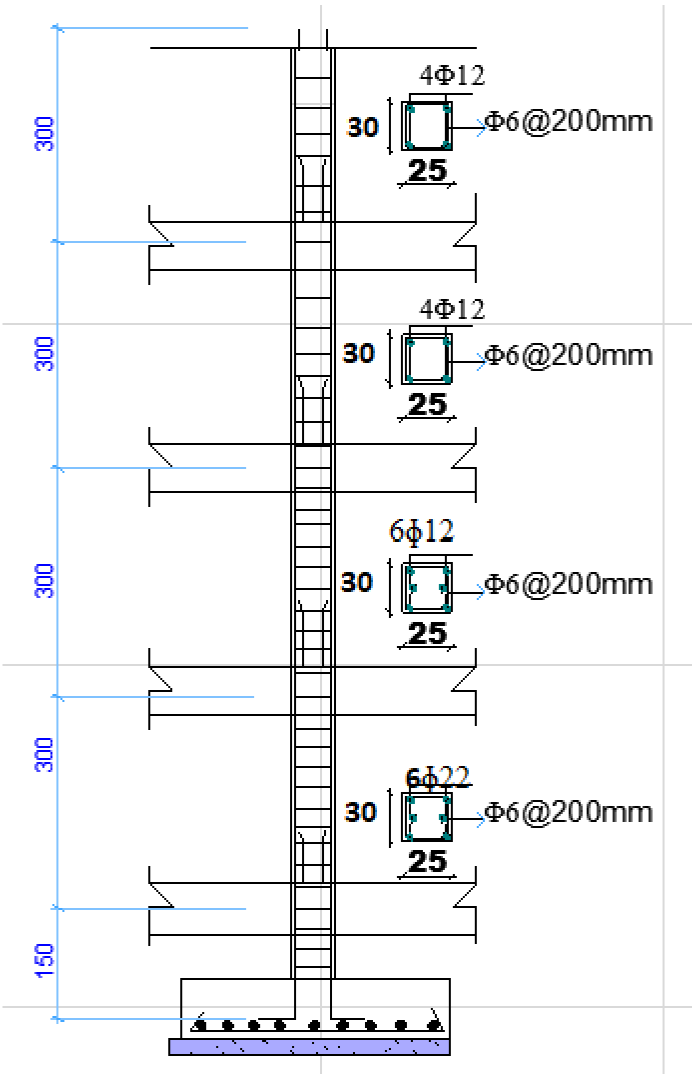


Figure4. 15. ***Steel arrangement in internal critical column***

4.7. Design of critical corner column

Column is the vertical structure member which carries the compressive loads from the beam and slabs down to the foundations. The column designed is the one loaded more than others and done by analytical method, the below calculations show how the column is calculated

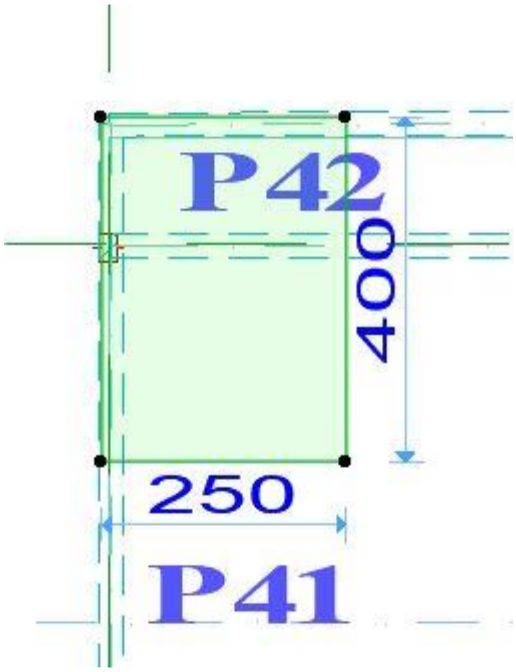


Figure4. 16. ***Critical corner column***

4.7.1. Calculation of dead load

Column cross section: 20cm*25cm=500cm^2

The height of the wall masonry =3m-0.500m=2.50m

The height of the area of the plaster=3m-0.16m=2.84m

Self-weight load of column= (1.4*0.20*0.25*3*24)KN=5.048KN

Permanent Load from the slab = (7.676*4*2.5) KN =76.76 KN

Live load from slab= 3.2*4*2.5=32KN

Load from the beam =1.4*0.50*0.25*(4+2.55)*24KN=27.3KN

Load from the Plaster=1.4*0.03*2.84*(4+2.5)*2*20KN=31.01KN

Load of Masonry wall =1.4*0.20*2.55*(4 +2.5)*19KN=77.8KN

Loads from the roof =76.76/2=38.38KN

N1= (76.76+32+27.3+31.01+77.8)*3+ (5.048*4)+38.38=797.182 KN

Slender ratio

$$\boldsymbol{\lambda} = \frac{0.7\text{h}}{\text{a}} = \frac{0.7 * 350}{20} = 12.25 \leq 14(\text{no slender, column is short})$$

Table4. 6. Slender ratio

λ	6	8	10	12	14	16	18	20
Φ	0.92	0.91	0.89	0.86	0.82	0.77	0.71	0.64

From the table φ is 0.82

Required steel reinforcement on ground floor part of the column

$$As = \frac{\frac{N}{\varphi} - Rb * Ab}{Rs} = \frac{\frac{797.172}{0.82} - 1.3 * 20 * 25}{40} = 8.02cm^2$$

Let as take 4Φ16 with As =8.04cm^2

The percentage of the As with respect to column cross section must lie between 0.4% and 4%

In this case we have [(8.04*100)/500] %=1.6%   the steel reinforcement are (OK)

1stfloor part

N1= (76.76+32+27.3+31.01+77.8)*2+ (5.048*3) +38.38=543.264 KN

Slender ratio

$$\boldsymbol{\lambda} = \frac{0.7h}{a} = \frac{0.7 * 300}{20} = 10.5 \leq 14(\text{no slender, column is short})$$

Table4. 7. Slender ratio

λ	6	8	10	12	14	16	18	20
Φ	0.92	0.91	0.89	0.86	0.82	0.77	0.71	0.64

From the table φ is 0.86

$$As = \frac{\frac{N}{\varphi} - Rb * Ab}{Rs} = \frac{\frac{543.264}{0.86} - 1.3 * 20 * 25}{40} = -0.45cm^2$$

Let as take 4Φ12withAs=4.52cm^2

For the second floor, The negative sign means that only the concrete is able to support the load, however we cannot make a plain concrete column without steel bars, therefore let's use As of 4.52cm^2 The percentage of the As with respect to column cross section must lie between 0.4% and 4% In this case we have [(4.52*100)/750] %=0.60% (OK)

2nd floor part

N1= (76.76+32+27.3+31.01+77.8)+ (5.048*2) +38.38=293.346 KN

Slender ratio

$$\boldsymbol{\lambda} = \frac{0.7\text{h}}{\text{a}} = \frac{0.7 * 300}{20} = 10.5 \leq 14(\text{no slender, column is short})$$

Table4. 8. Slender ratio

λ	6	8	10	12	14	16	18	20
Φ	0.92	0.91	0.89	0.86	0.82	0.77	0.71	0.64

From the table φ is 0.86

$$\text{As} = \frac{\frac{\text{N}}{\varphi} - \text{Rb} * \text{Ab}}{\text{Rs}} = \frac{\frac{293.346}{0.86} - 1.3 * 20 * 25}{40} = -7.722\text{cm}^2$$

Let as take 4Φ12withAs=4.52cm^2

For the second floor, The negative sign means that only the concrete is able to support the load, however we cannot make a plain concrete column without steel bars, therefore let's use As of 4.52cm^2 The percentage of the As with respect to column cross section must lie between 0.4% and 4% In this case we have [(4.52*100)/750] %=0.60% (OK)

3rdfloor part

N1= 27.3+31.01+77.8+5.048 +38.38=179.538KN

$$\text{As} = \frac{\frac{\text{N}}{\varphi} - \text{Rb} * \text{Ab}}{\text{Rs}} = \frac{\frac{179.538}{0.86} - 1.3 * 20 * 25}{40} = -11.03\text{cm}^2$$

Let as take 4Φ12withAs=4.52cm^2

For the second floor, The negative sign means that only the concrete is able to support the load, however we cannot make a plain concrete column without steel bars, therefore let's use As of 4.52cm^2 The percentage of the As with respect to column cross section must lie between 0.4% and 4% In this case we have [(4.52*100)/750] %=0.60% (OK)

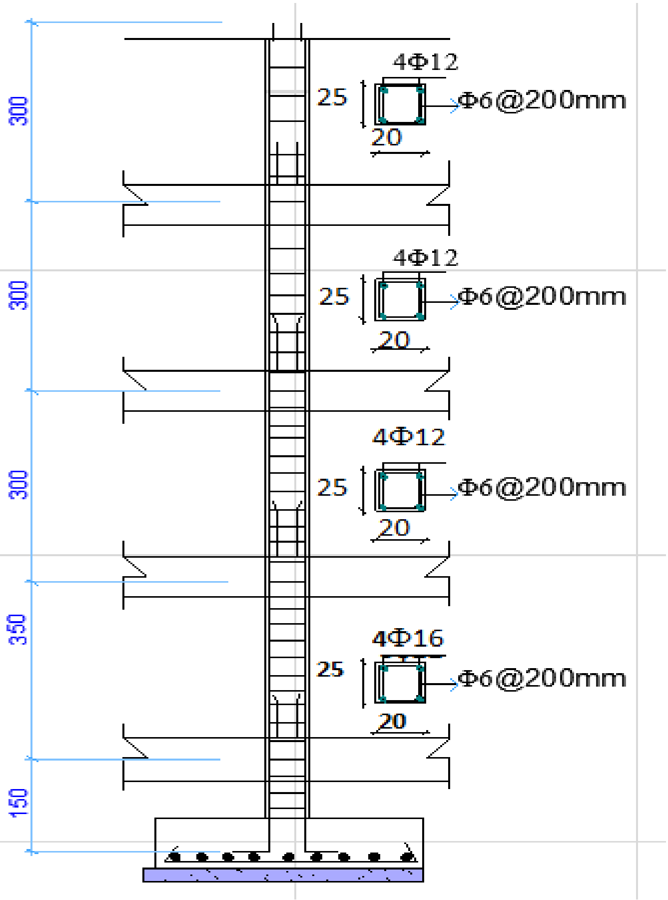


Figure4. 17. ***Critical corner column***

4.8. Design of pad foundation for the interior critical column

Foundations transfer loads from the building or individual columns to the earth. The type of foundation to be used is selected depending upon the soil properties and condition, the type of structure, loading and the permissible amount of differential settlement. Soil bearing capacity and settlement are two important elements to be considered in foundation design.

Computations of loads

Critical interior column design load=1567.719 KN

Total design live load=77.6KN *4KN=310.4KN

Total design dead load=1567.719 KN -310.4KN =1256.79KN

$$\text{Total characteristic live load} = \frac{310.4}{1.6} = 194\text{KN}$$

$$\text{Total characteristic permenent load} = \frac{1256.79}{1.4} = 897.70\text{KN}$$

Total characteristic load=194KN +897.70KN =1091.7KN

$$\text{Estimated foundation weight} + \text{soil on it} = \frac{1091.7\text{KN} * 10}{100} = 109.17\text{KN}$$

Total load on the soil=1091.7KN +109.17KN =1201.61 KN

The required area of the foundation

Bearing capacity of soil=300KN/m^2=0.03KN/cm^2

$$\text{Af} = \frac{\text{Total load on the soil}}{\text{Bearing capacity}} = \frac{1201.61\text{ KN}}{0.03} = 40053.9\text{cm}^2$$

$$\text{Af} = \sqrt{40053.9\text{cm}^2} = 200.13\text{cm}$$

Let’s take A_f =200cm*200cm

Design soil pressure (p)

$$\text{P} = \frac{\text{N}}{\text{Af}} = \frac{1567.719\text{ KN}}{200\text{cm} * 200\text{cm}} = \frac{0.0393\text{KN}}{\text{cm}^2}$$

ac =25cm

bc =30cm

$$\text{Horizontal distance from the column to the edge of foundation} = \frac{200 - 25}{2} = 87.5\text{cm}$$

Let’s take the thickness of foundation

h= 55cm

ho =h-concrete cover

ho =55cm- 5m=50cm

Distance where punching soil pressure applied= (lc-ho) 87.5cm-50cm=37.5cm

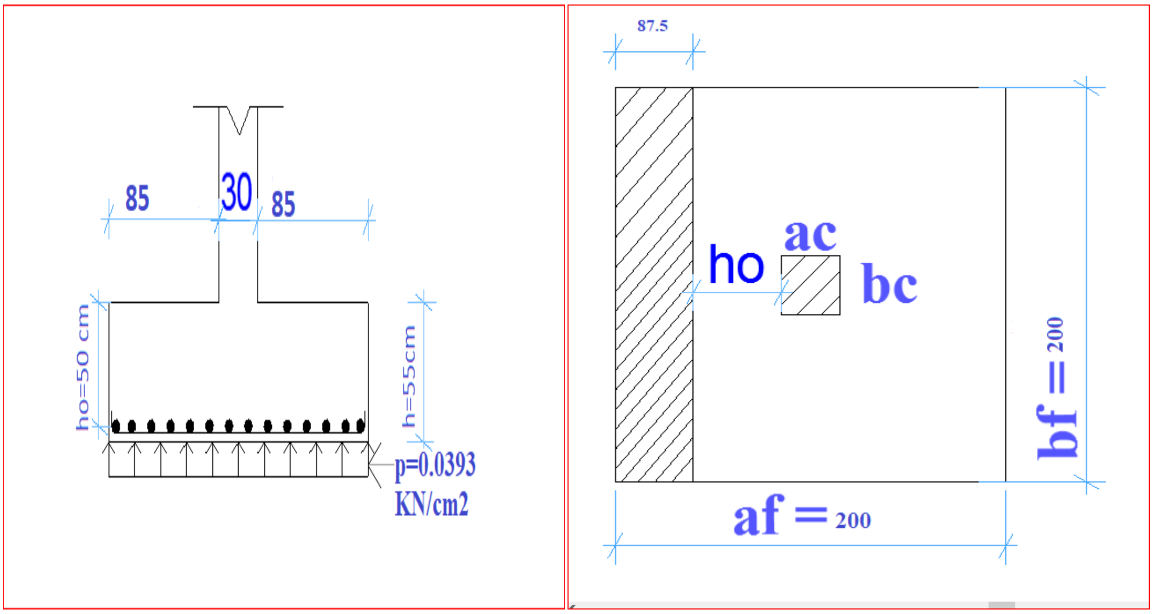


Figure4. 18. : *Footing cross section parameter*

Shear

Q≤0.54Rbt*Ab

Where Ab=af *ho

A_f =200cm

R_{bt}=0.09

Q=P*bf (lc-ho) =0.0364*200*22.5=155.61KN

Q≤0.54*0.09*200*60=554.04KN

Q=155.61KN ≤ 554.04KN OK

CHECKING FOR PUNSHING SHEAR

Qf = Nf-Δq ≤ Rbt*Ab

Where Ab=Um*ho,

Um=2(ac+bc +2ho),

Um=2(25+25+2*60) =340cm

Ab=340*60=20400cm^2

Δq=P (ac+2ho) (bc+2ho) =0.0364 (25+2*60) (25+2*60)= 765.31KN

Qf =1316.48-765.31≤0.09*20400

551.17KN ≤ 1836KN OK

Moment calculation

$$\text{Mmax} = \frac{P * af}{2}\left(\frac{bf - bc}{2}\right)^2 = \left(\frac{0.0393 * 200}{2}\right)\left(\frac{200 - 25}{2}\right)^2 = 60178.01\text{KNcm}$$

$$\text{As} = \frac{\text{Mmax}}{0.9 * ho * Rs} = \frac{60178.01\text{KNcm}}{0.9 * 60 * 40} = 27.86\text{cm}^2$$

Steel reinforcement arranged in 2 m has a total cross section 27.86cm^2 and the steel reinforcement to be arranged a long 1m have total cross section of

27.86 cm^2/2m= 13.93cm^2/m

Supposing 5 bars arranged along 1m and The total numbers of steel bars that will be arranged in 2 m are 14 bars having a total cross section of 27.86cm^2

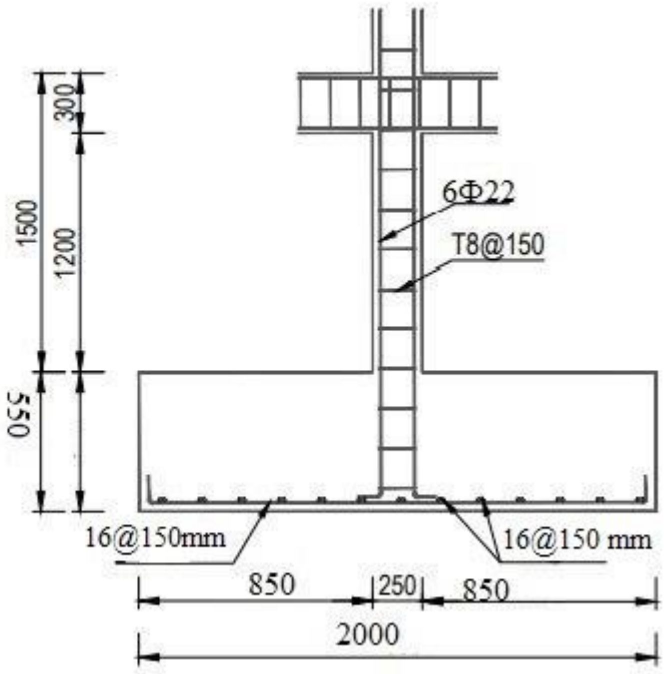


Figure4. 19. ***Interior critical footing detail of reinforcement***

4.9. Design of pad foundation for the corner critical column

Foundations transfer loads from the building or individual columns to the earth. The type of foundation to be used is selected depending upon the soil properties and condition, the type of structure, loading and the permissible amount of differential settlement. Soil bearing capacity and settlement are two important elements to be considered in foundation design.

Computations of loads

Critical interior column design load=797.182 KN

Total design live load=32KN *4KN=128KN

Total design dead load=797.182 KN-128KN =669.128KN

$$\text{Total characteristic live load} = \frac{128\text{KN}}{1.6} = 91.4\text{KN}$$

$$\text{Total characteristic permenent load} = \frac{669.128\text{KN}}{1.4} = 477.94\text{KN}$$

Total characteristic load=91.4KN +477.94KN =569.34KN

$$\text{Estimated foundation weight} + \text{soil on it} = \frac{569.34\text{KN} * 10}{100} = 56.934\text{KN}$$

Total load on the soil=569.34KN +56.934KN =626.274 KN

The required area of the foundation

Bearing capacity of soil=300KN/m^2=0.03KN/cm^2

$$\text{Af} = \frac{\text{Total load on the soil}}{\text{Bearing capacity}} = \frac{626.274}{0.03} = 20875.8\text{cm}^2$$

$$\text{Af} = \sqrt{20875.8\text{cm} =}144.48\text{cm}$$

Let’s take A_f =145cm*145cm

Design soil pressure (p)

$$\text{P} = \frac{\text{N}}{\text{Af}} = \frac{797.182\ \text{KN}}{145\text{cm} * 145\text{cm}} = \frac{0.0379\text{KN}}{\text{cm}^2}$$

ac =25cm

bc =20cm

Shear

Q≤0.54Rbt*Ab

Where Ab=af *ho

A_f =145cm

R_{bt}=0.09

Q=P*bf (lc-ho) =0.0379*200*22.5=170.55KN

Q≤0.54*0.09*145*50=3352.32KN

Q=170.55KN ≤ 3352.32KN OK

CHECKING FOR PUNSHING SHEAR

Qf = Nf-Δq ≤ Rbt*Ab

Where Ab=Um*ho,

Um=2(ac+bc +2ho),

Um=2(25+20+2*50) =290cm

Ab=290*50=14500cm^2

Δq=P (ac+2ho) (bc+2ho) =0.0379 (25+2*50) (25+2*60)= 765.31KN

Qf =1316.48-765.31≤0.09*20400

551.17KN ≤ 1836KN OK

Moment calculation

$$\text{Mmax} = \frac{\text{P} * \text{af}}{2}\left(\frac{\text{bf} - \text{bc}}{2}\right)^2 = \left(\frac{0.03739 * 145}{2}\right)\left(\frac{145 - 25}{2}\right)^2 = 10756\text{KNcm}$$

$$\text{As} = \frac{\text{Mmax}}{0.9 * \text{ho} * \text{Rs}} = \frac{9756\text{KNcm}}{0.9 * 50 * 40} = 6.02\text{cm}^2$$

Steel reinforcement arranged in 1.45 m has a total cross section 6.02cm^2 and the steel reinforcement to be arranged a long 1m have total cross section of

6.02 cm^2/1.45m

Supposing bars arranged along 1.45m we take 7 ϕ12with As =1407cm^2/m

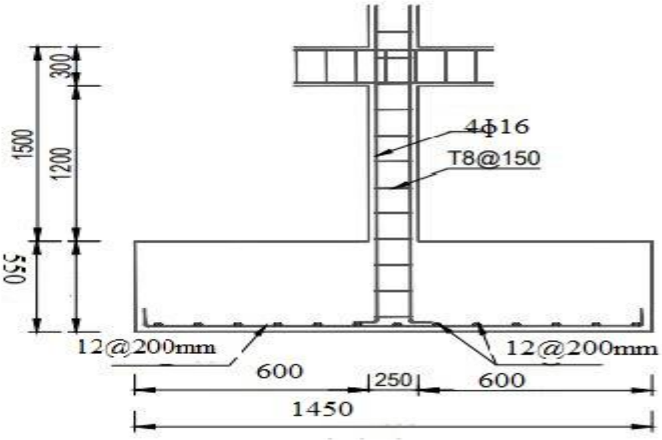


Figure4. 20. ***Critical corner footing***

4.10. Design of stair

A stair is a set of steps leading from one floor of a building to another, typically inside the building. The room or enclosure of the building, in which the stair is located, is known as staircase. This stair contains three parts: rise, tread and waist.

Figure: stair case location in the structural drawing and its dimensions

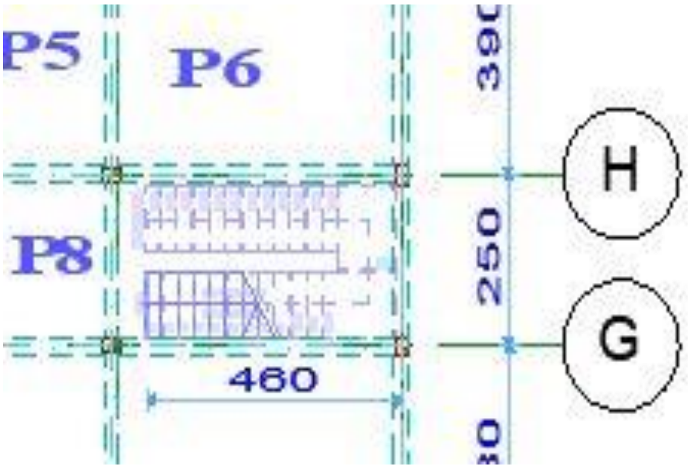


Figure4. 21. ***Stair structural plan.***

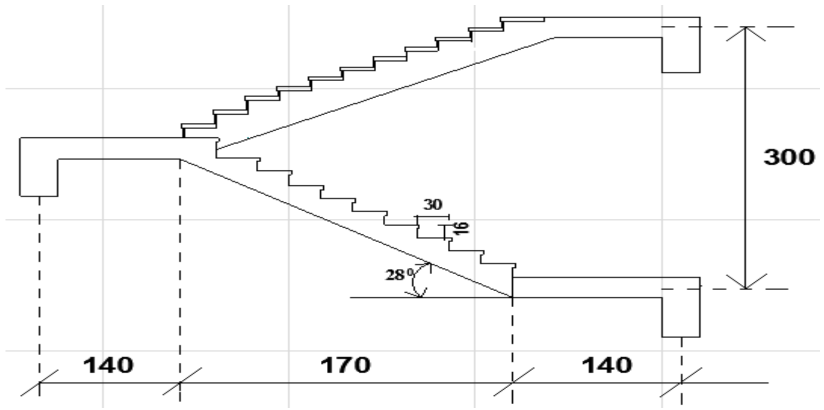


Figure4. 22. ***The stair and its dimensions***

The usual form of stairs can be classified into two types

Those spanning horizontally in the transverse direction and

Those spanning longitudinally.

Stair spanning longitudinally may span into landings or it may span between supporting beams like for this case, the dead load is calculated along the slope length of the stair but the live load is based on the plan area.

Computation of equivalent height (h_L) and effective height of the cross section (h_o).

d_l =15cm

Rise =16cm

Going=30cm

$$\theta = \tan^{-1}\left(\frac{\text{rise}}{\text{going}}\right) = \tan^{-1}\frac{16}{30} = 28^{o}$$

$$\text{He} = \frac{\text{dl}}{\cos\theta} + \frac{\text{a}}{2} = \frac{15}{\cos 28} + \frac{16}{2} = 25\text{cm}$$

$H_o = H_e$- concrete cover = 25cm - 2.5cm =22.5cm

Determination of loadings on flight.

Dead load = 1.4*0.25*1*1*24 = 8.4KN/m^2

Finishes = 1.4*1.5 = 2.1 KN/m^2

Live load = 1.6*2 = 3.2 KN/m^2

Total design load (P) = 8.4+2.1+3.2= 13.7KN/m^2

The load for landing stair is the same as the total design load for slab which is equal to P = 10.676KN/m^2

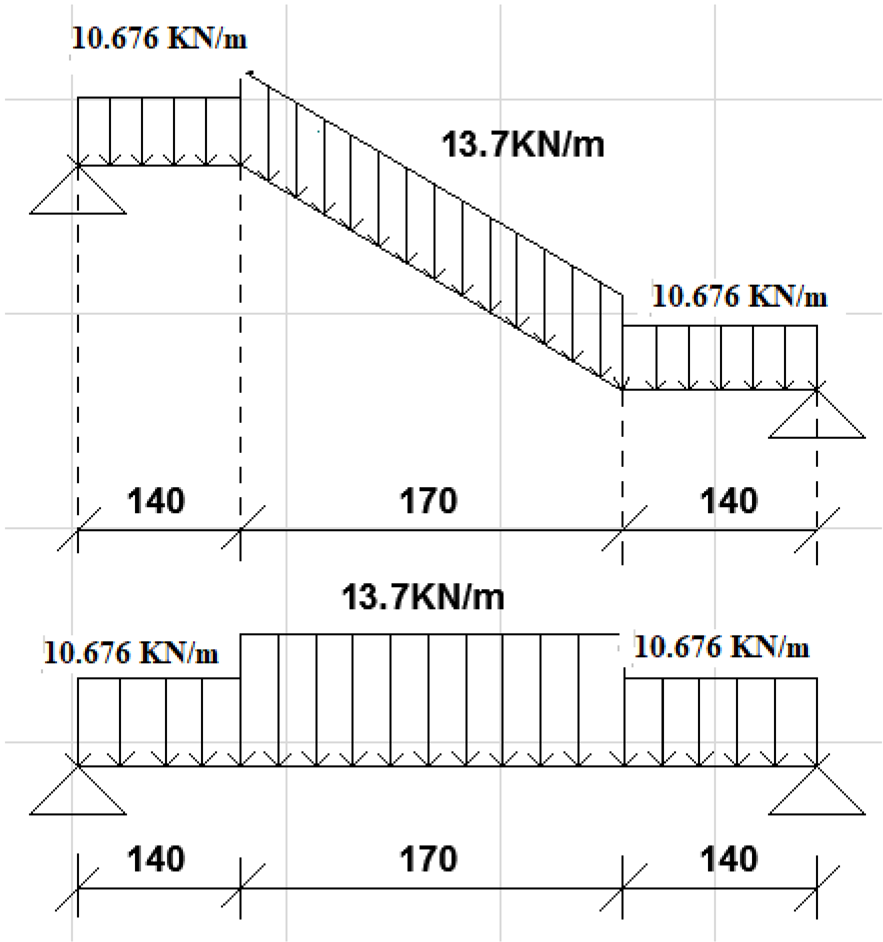


Figure4. 23. ***Loadings on the stairs***

Determination of reaction and moment

$\Sigma F_v=0$,

$A_y + B_y= (10.34*1.4) + (13.7*1.7) + (10.34*1.4) = 52.24KN$

$-3.5Ay+ (10.34*1.4*3.8) + (13.7*1.7*2.25) + (10.34*\frac{1.4^2}{2})=0$

3.5Ay=117.54

$$Ay = \frac{117.54}{3.5} = 33.58KN$$

By=52.24KN-33.58KN=18.65KN

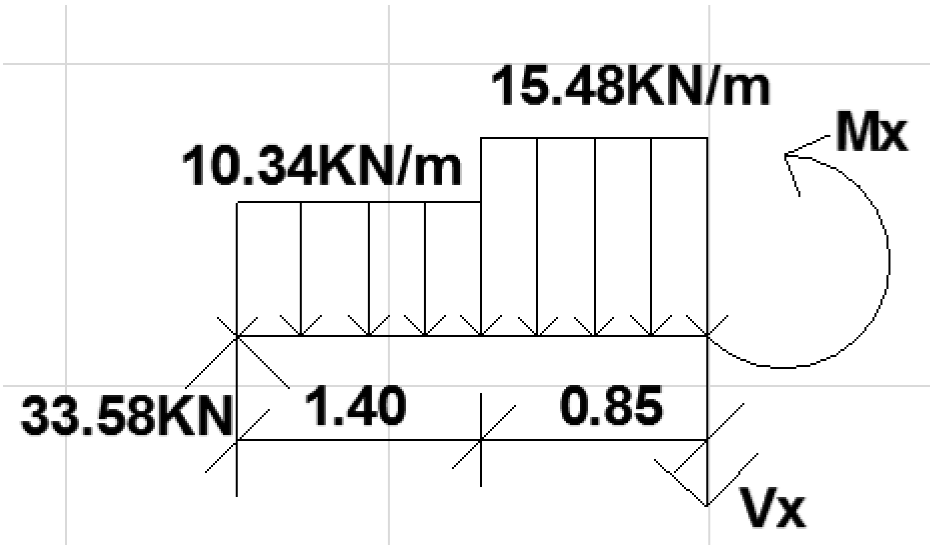


Figure4. 24. ***Stair moment calculation***

ΣMx=0,

$$\text{Mmax} = 33.58 * 2.05 - (10.34 * 1.4 * 2.25) - \left(13.7 * \frac{1.4^2}{2}\right)$$

$$= 22.84\text{KNm}$$

Required steel reinforcement at the bottom

$$\underline{\alpha}\text{m} = \frac{\text{M} * 100}{\text{Rb} * \text{ho}^2 * \text{b}} = \frac{22.84 * 100}{1.3 * (22.5)^2 * 100} = 0.034$$

ξ= 0.04; <ξR=0.393 (Case of singly reinforcements)

η=0.980

$$\text{As} = \frac{\text{M}^+}{\eta * \text{ho} * \text{RS}} = \frac{22.84 * 100}{0.958 * 22.5 * 40} = 2.64\text{cm}^2/\text{m}$$

Let's take 6Φ10/m with A_s = 4.41cm^2/m

Required steel reinforcement at the top let's consider the minimum steel reinforcement 6Φ8/m with A_s = 3.02cm^2/m

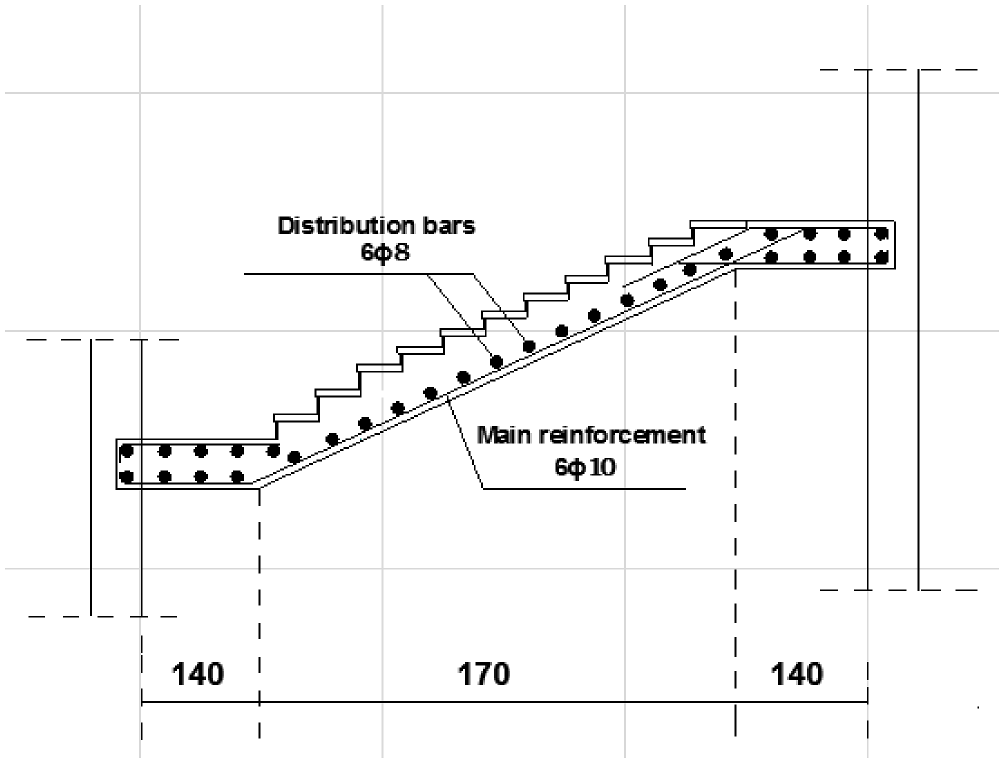


Figure4. 25. ***Stair reinforcement details***

4.11. Design of ramp

A Ramp is a sloping surface connecting two levels from one floor to another; its incline. The design results for the critical ramp flight panel. The provided thickness satisfies the deflection control and also the cracks are within the allowable limits

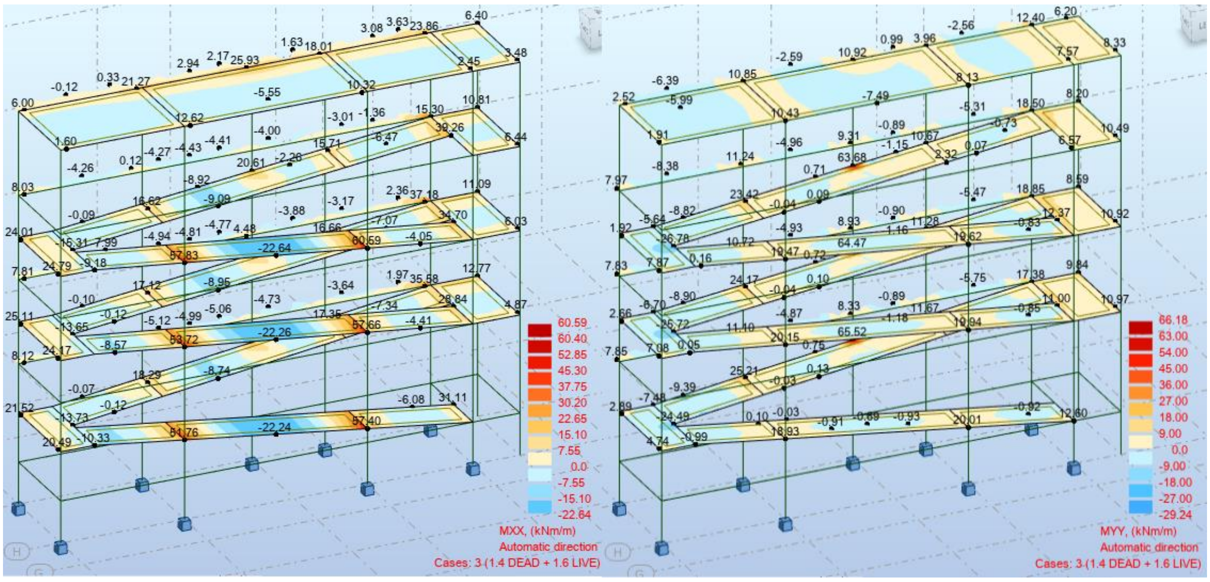


Figure4. 26. ***Bending moment in ramp***

4.11.1 Ramp flight

Concrete

- Class : C25; Characteristic strength = 25000.00 kPa
- Density : 24.53 (kN/m3)
- Concrete creep coefficient : 2.10

4.11.2 Slab Geometry

Thickness 0.20 (m)

Deflection

|f(+)| = 0.0 (cm) <= fdop(+) = 3.0 (cm)

|f(-)| = 2.9 (cm) <= fdop(-) = 3.0 (cm)

Cracking

upper layer

ax = 0.13 (mm) <= adop = 0.30 (mm)

ay = 0.12 (mm) <= adop = 0.30 (mm)

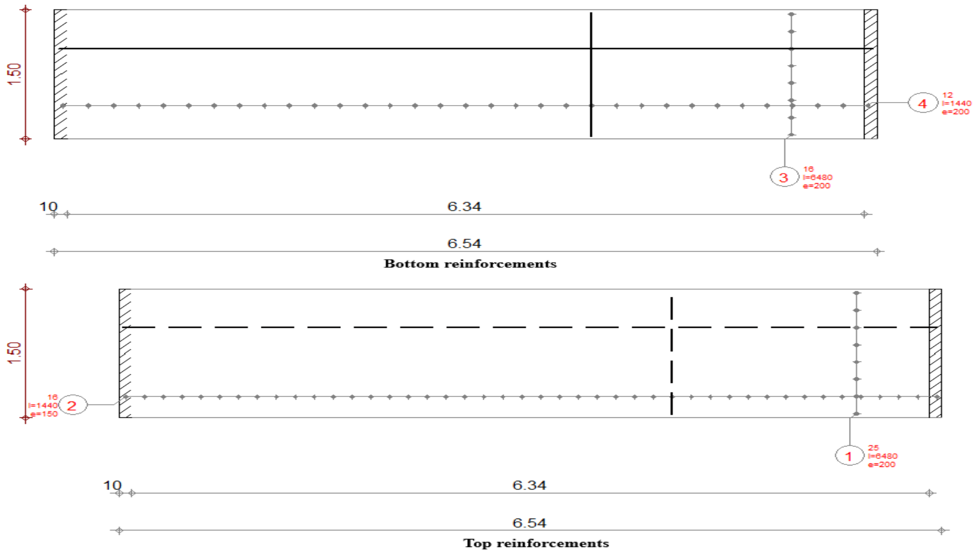
lower layer

ax = 0.08 (mm) <= adop = 0.30 (mm)

ay = 0.00 (mm) <= adop = 0.30 (mm)

Table4. 9. Required reinforcement in ramp flight

reinforcement	Required area	Total area
Bottom reinforcement		
1/1- Ax Main	16.0 / 200.0	814.14
1/2- Ay Perpendicular	12.0 / 200.0	551.38
Top reinforcement		
1/1+ Ax Main	25.0 / 200.0	2430.09
1/2+ Ay Perpendicular	16.0 / 150.0	1021.80



Pos.	Reinforcement	Code	Shape	Number
1	25 l=6480	00	6480	8
2	16 l=1440	00	1440	44
3	16 l=6480	00	6480	8
4	12 l=1440	00	1440	33

Figure4. 27. ***Ramp flight reinforcement***

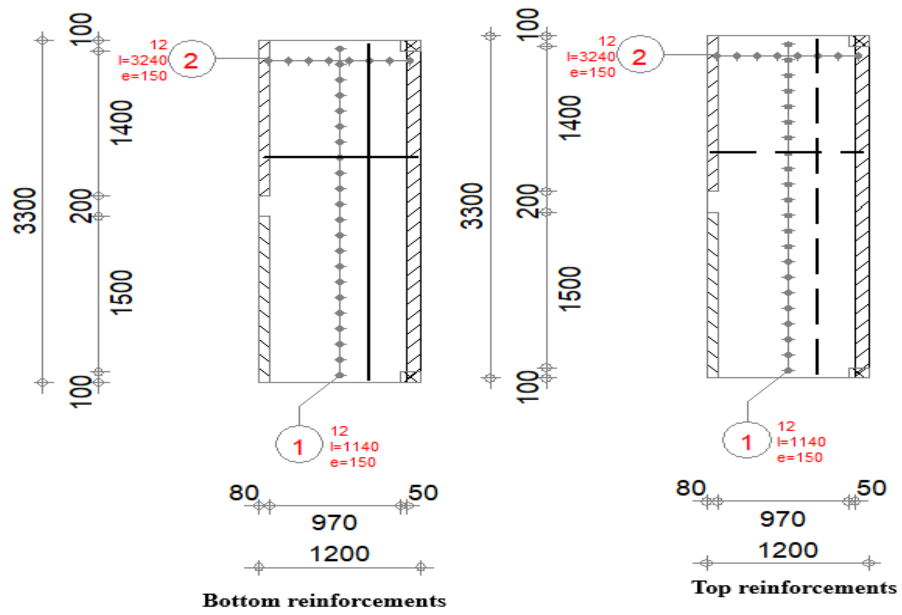
4.11.3 Ramp landing

Table4. 10. Maximum moment and deflection in ramp landing

no	description		Result			
1.	1. Maximum moments (kN.m/m)	location	Top		Bottom	
		Direction	X-direction	Y direction	X direction	Y-direction
		ULS	24.35	24.35	-3.18	-0.41
		SLS	16.86	16.86	-0.24	-0.24
2	Deflection (mm)		**Maximum**		**Allowable**	
			17		30	

Table4. 11. Required reinforcement in ramp landing

reinforcemen	Required area	Total area
Bottom reinforcement		
1/1- Ax Main	12.0 / 150.0	208.00
1/2- Ay Perpendicular	12.0 / 150.0	672.31
Top reinforcement		
1/1+ Ax Main	12.0 / 150.0	669.20
1/2+ Ay Perpendicular	12.0 / 150.0	298.65



Pos.	Reinforcement		Code	Shape	Number
1	12	l=1140	00	1140	44
2	12	l=3240	00	3240	16

Figure4. 28. ***Ramp landing reinforcement***

4.12. Design of the shear wall

The lift shear wall is a wall in which contains the lift.

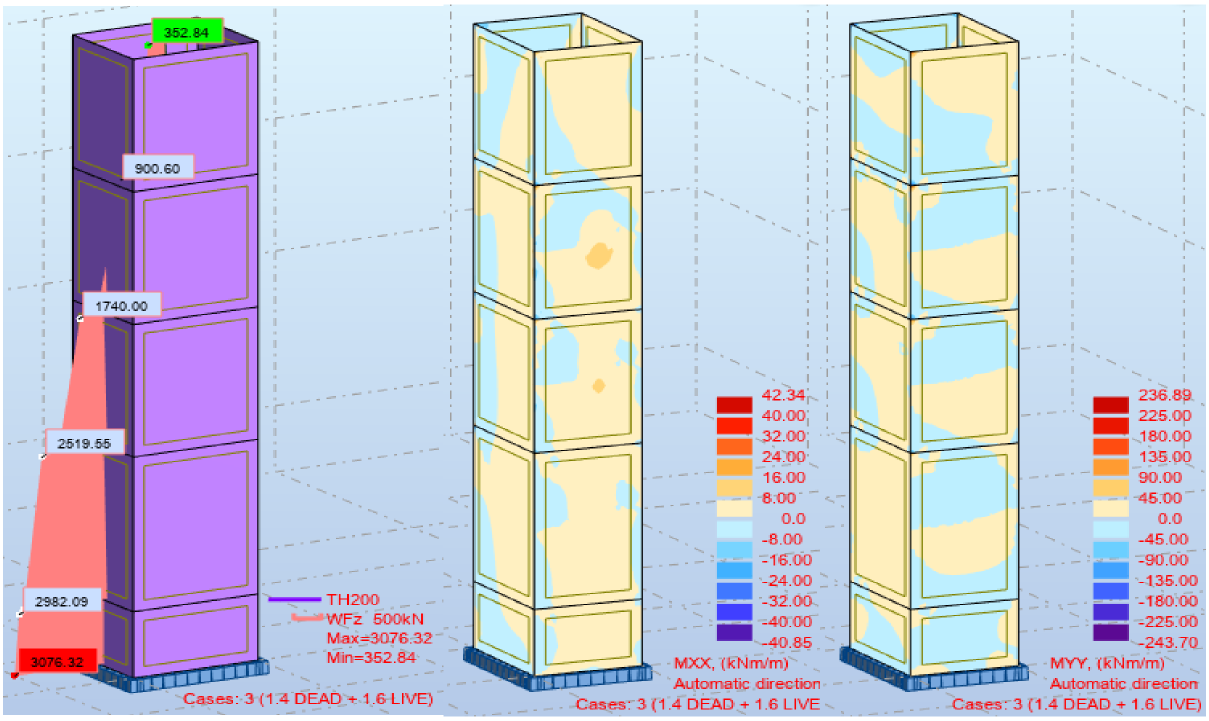


Figure4. 29. ***Bending moments and axial forces in the lift shear wall***

4.12.1.Material properties:

- Concrete : C25 fck = 25000.00 (kPa) Density = 24.53 (kN/m3)
- Longitudinal reinforcement : type T fe = 460000.00 (kPa)
- Transversal reinforcement : type T fe = 460000.00 (kPa)
- Concrete age (loading moment) : 28

4.12.2. Geometry:

Name: P1

Length: 2.70 (m)

Thickness: 0.20 (m)

Height: 3.50 (m)

Ring beam height: 0.00 (m)
Vertical support: ---------
Support conditions : Floor adjoining on two sides

4.12.3 Calculation options:

Cover :22.0 (mm)

Seismic dispositions:none

Buckling length

Lo = b * Lw

Lo = 2.98 (m)

Slenderness

l = Lo / i

l = 51.53

4.12.4 Design combination: ULS 1

f cvd = 1329.78 (kPa)

t cp = 177.20 (kPa)

Table4. 12. Reinforcement in shear wall

Vetical reinforcement						
Zone xo (m)	X1(m)	Number	steel	Diameter(mm)	Length(m)	Spacing (m)
0.20	2.50	20	T	12.0	4.24	0.25

Horizontal reinforcement								
Type	Number	Steel	Diameter (mm)	A (m)	B (m)	C (m)	Spacing	Shape
Straight bars	28	T	8.0	2.66	0	0	2.25	
U loop	14	T	8.0	0.53	0.14	0.53	-	21
U loop	14	T	8.0	0.53	0.14	0.53	-	21

Pins						
Number 70	Steel	Diameter (mm)	A (m)	B (m)	C (m)	shape
	T	8.0	0.16	0	0	-

Edge reinforcement (Af):							
position	number	steel	diameter(mm)	A(m)	B(m)	C(m)	shape
Longitudinal reinforcement - left side	4	T	12	4.24	0	0	-
Longitudinal reinforcement - right side	4	T	12	4.24	0	0	-
Transversal reinforcement - left side	14	T	8	0.16	0.16	0.16	31
Transversal reinforcement - right side	14	T	8	0.16	0.16	0.16	31

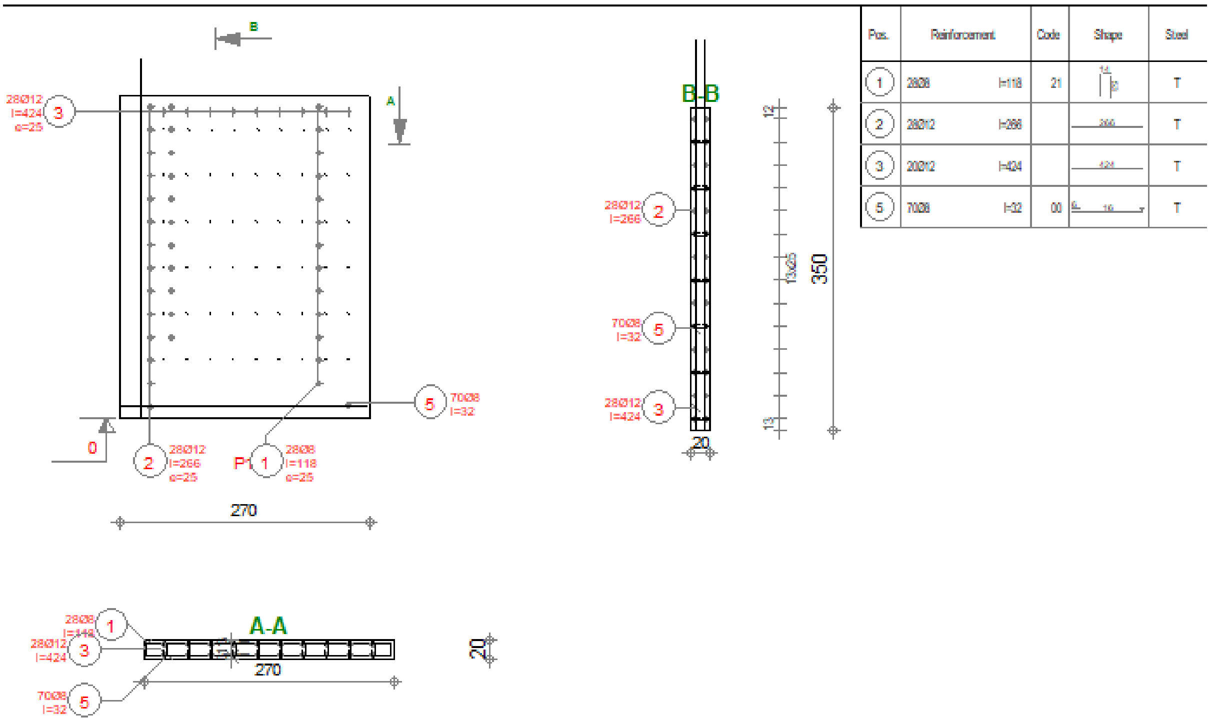


Figure4. 30. ***Shear wall reinforcement shown by software***

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

This chapter discus on the research conclusions found after the analysis of the results and the verification of the research question. This chapter also highlights the suggested recommendations related to the research findings.

5.1. Conclusion

Rwanda is a landlocked country with small area of 26,338 Km^2 and high density of population. Its rapidly increasing population challenges its infrastructural development; it is required to provide a proper management of land use and modern buildings for better Educational service. This project has an objective of architectural and structural designing of four-storied public library building that will effectively contribute in minimizing problems of lack of libraries.

Objectives of performing this project have been achieved, as design of elements such as roof, beam, slab, column, stair, foundation and ramp were designed used architectural drawing was also necessary, arch cad software was used in drawing and for structural design details, software was used for showing bending, shear diagrams, analysis of frame and provide reinforcement by using manual and Autodesk robot with: BS 8110. This overall project can help those who will refer to it, especially next students who will perform the structural design projects, also the private sector of Rwanda will use it even in case of implementing the Public Library building in Gasabo District in order to get a good living place with educational improvements in our Country.

5.2. Recommendations

During the implementation of this project, many problems and challenges were encountered that is why we would like to suggest the following recommendations:

1. To respect design rules of structural elements such as roof slab, beam, columns and footing (Example: number of steel bars provided should be respected, size of structural elements must be respected, use strong materials during it construction.).

REFERENCE

Bencardino, F., Rizzuti, L., Spadea, G., & Swamy, R. N. (2008). Stress-strain behavior of steel fiber-reinforced concrete in compression. *Journal of Materials in Civil Engineering*, *20*(3), 255-263**.**

Blezard, R. G. (2004). *The history of Calcareous Cements* (4th ed.). Amsterdam: Elsevier Butterworth-Heinemann. pp 22-34.

Carino, N. J. (1994). Concrete Technology.*American Concrete Institute*, *13*(3), 623-625.

Choo, B. S., & MacGinley, T. J. (2002). *Reinforced concrete: design theory and examples* (2nd ed.). London: CRC Press. pp 45-56.

Chrest, A. P., Smith, M. S., Bhuyan, S., Iqbal, M., & Monahan, D. R. (2012). *Parking structures: Planning, Design, Construction, Maintenance and Repair.* London: Springer Science & Business Media. pp 368-387.

Collins, J. A. (1993). *Failure of materials in mechanical design: analysis, prediction, prevention.* Chicago: John Wiley & Sons. Pp 450.

Condit, C. W. (1968). The first Reinforced-Concrete Skyscraper: The Ingalls Building in Cincinnati and Its Place in Structural History. *Technology and Culture, 9*(1), 1-33.

Demirbas. (1996). Optimizing the physical and technological properties of cement additives in concrete mixtures. *Cement and Concrete Research*, 26 (11), 1737 – 1744.

Eastman, C., Lee, J. M., & Jeong, Y. S. (2009). Automatic rule based checking of building designs. *Automation in Construction, 18*(8), 1011-1033.

Garber, G. (2006). *Design and construction of concrete floors* (2nd ed.). Amsterdam: Butterworth-Heinemann. pp 675.

Harris, C. M. (2000). *Dictionary of Architecture and Construction* (3rd ed.). New York: McGraw Hill. pp 775.

Hanna & Mayerhof. (1980). Design charts for ultimate bearing capacity of foundations on sand overlaying soft clay. *Canadian Geotechnical Journal, 17* (2), 300-303.

Lan, L., Wargocki, P., Wyon, D. P., & Lian, Z. (2011). Effects of thermal discomfort in an office on perceived air quality, SBS symptoms. *Physiological Responses, and Human Performance. Indoor Air, 5*(21), 376-390.

Kaprisin, R. (2011). Urban design: the composition of complexity (4th ed.). New York: Taylor & Francis. pp 57-62.

Mosley, W. H., Hulse, R., & Bungey, J. H. (2012). *Reinforced Concrete Design: to Eurocode 2* (4th ed.). Texas: Palgrave macmillan.

.

Maslehuddin, M., Sharif, A. M., Shameem, M., Ibrahim, M., & Barry, M. S. (2003). Comparison of properties of steel slag and crushed limestone aggregate concretes. *Construction and Building materials*, *17*(2), 105-112.

Phillips, T. S. (2003). *Building type basics for justice facilities.* Newyork: John Wiley and Sons, pp 456-463.

Venkataraman, R., Pinto, J. (2008). *Cost and Value Management in Projects* (3rd ed.). New Jesey: John Wiley & Sons.pp476.

Zimmerman, A. (2001). Post-occupancy evaluation. Benefits and barriers. *Building Research & Information*, *2*(29), 168-174.

APPENDICES

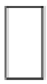
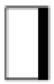
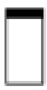
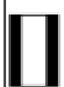
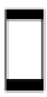
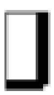
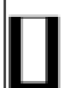
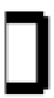
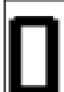
Appendix 1. Sectional areas of groups of bars (mm2)

Bar size (mm)	Number of bars													Weight (Kg/m)
	1	2	3	4	5	6	7	8	9	10	11	12	14	
6	28.3	56.5	85	113	141	170	198	226	254	283	311	339	396	0.222
8	50.3	101	151	201	251	302	352	402	452	503	553	603	704	0.395
10	79	157	236	314	393	471	550	628	707	785	864	942	1100	0.617
12	113	226	339	452	565	679	792	905	1018	1131	1244	1357	1583	0.888
14	154	308	462	616	770	924	1078	1232	1385	1539	1693	1847	2155	1.208
16	201	402	603	804	1005	1206	1407	1608	1810	2011	2212	2413	2815	1.578
18	254	509	763	1018	1272	1527	1781	2036	2290	2545	2799	3054	3563	1.998
20	314	628	942	1257	1571	1885	2199	2513	2827	3142	3456	3770	4398	2.466
22	380	760	1140	1521	1901	2281	2661	3041	3421	3801	4181	4562	5322	2.984
24	452	905	1357	1810	2262	2714	3167	3619	4072	4524	4976	5429	6333	3.551
25	491	982	1473	1963	2454	2945	3436	3927	4418	4909	5400	5890	6872	3.853
26	531	1062	1593	2124	2655	3186	3717	4247	4778	5309	5840	6371	7433	4.168
28	616	1232	1847	2463	3079	3695	4310	4926	5542	6158	6773	7389	8621	4.834
30	707	1414	2121	2827	3534	4241	4948	5655	6362	7069	7775	8482	9896	5.549
32	804	1608	2413	3217	4021	4825	5630	6434	7238	8042	8847	9651	11259	6.313
34	908	1816	2724	3632	4540	5448	6355	7263	8171	9079	9987	10895	12711	7.127
36	1018	2036	3054	4072	5089	6107	7125	8143	9161	10179	11197	12215	14250	7.990
38	1134	2268	3402	4536	5671	6805	7939	9073	10207	11341	12475	13609	15878	8.903
40	1257	2513	3770	5027	6283	7540	8796	10053	11310	12566	13823	15080	17593	9.865

Apendix 2. Coefficients related to the design of members subjected to bending moment

ξ	$\alpha m = \frac{M}{Rb*b*h^2}$	η	ξ	$\alpha m = \frac{M}{Rb*b*h^2}$	η
0.01	0.010	0.995	0.37	0.302	0.815
0.02	0.020	0.990	0.38	0.308	0.810
0.03	0.030	0.985	0.39	0.314	0.805
0.04	0.039	0.980	0.40	0.320	0.800
0.05	0.049	0.975	0.41	0.326	0.795
0.06	0.058	0.970	0.42	0.332	0.790
0.07	0.068	0.965	0.43	0.338	0.785
0.08	0.077	0.960	0.44	0.343	0.780
0.09	0.086	0.955	0.45	0.349	0.775
0.10	0.095	0.950	0.46	0.354	0.770
0.11	0.104	0.945	0.47	0.360	0.765
0.12	0.113	0.940	0.48	0.365	0.760
0.13	0.122	0.935	0.49	0.370	0.755
0.14	0.130	0.930	0.50	0.375	0.750
0.15	0.139	0.925	0.51	0.380	0.745
0.16	0.147	0.920	0.52	0.385	0.740
0.17	0.156	0.915	0.53	0.390	0.735
0.18	0.164	0.910	0.54	0.394	0.730
0.19	0.172	0.905	0.55	0.399	0.725
0.20	0.180	0.900	0.56	0.403	0.720
0.21	0.188	0.895	0.57	0.408	0.715
0.22	0.196	0.890	0.58	0.412	0.710
0.23	0.204	0.885	0.59	0.416	0.705
0.24	0.211	0.880	0.60	0.420	0.700
0.25	0.219	0.875	0.61	0.424	0.695
0.26	0.226	0.870	0.62	0.428	0.690
0.27	0.234	0.865	0.63	0.432	0.685
0.28	0.241	0.860	0.64	0.435	0.680

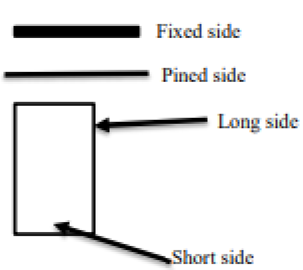
Apendix 3. Coefficients related to the design of slabs

Panel	coefficients		$\lambda = \frac{L_y}{L_x}$							
			1.0	1.1	1.2	1.3	1.4	1.5	1.7	2.0
	Short side α_{sx}	M^-	-	-	-	-	-	-	-	-
		M^+	0.037	0.044	0.051	0.059	0.066	0.072	0.083	0.095
	Long side α_{sy}	M^-	-	-	-	-	-	-	-	-
		M^+	0.037	0.036	0.036	0.035	0.034	0.032	0.029	0.024
	Short side α_{sx}	M^-	0.089	0.098	0.105	0.110	0.113	0.116	0.119	0.122
		M^+	0.033	0.038	0.043	0.047	0.050	0.053	0.057	0.061
	Long side α_{sy}	M^-	-	-	-	-	-	-	-	-
		M^+	0.027	0.025	0.024	0.022	0.020	0.018	0.015	0.011
	Short side α_{sx}	M^-	-	-	-	-	-	-	-	-
		M^+	0.027	0.034	0.042	0.049	0.055	0.062	0.074	0.089
	Long side α_{sy}	M^-	0.089	0.096	0.098	0.099	0.098	0.094	0.084	0.068
		M^+	0.033	0.035	0.035	0.035	0.035	0.034	0.032	0.028
	Short side α_{sx}	M^-	0.069	0.073	0.076	0.078	0.079	0.080	0.081	0.082
		M^+	0.027	0.027	0.031	0.033	0.034	0.035	0.036	0.038
	Long side α_{sy}	M^-	-	-	-	-	-	-	-	-
		M^+	0.018	0.016	0.014	0.013	0.011	0.010	0.009	0.006
	Short side α_{sx}	M^-	-	-	-	-	-	-	-	-
		M^+	0.018	0.024	0.031	0.037	0.043	0.051	0.064	0.080
	Long side α_{sy}	M^-	0.069	0.076	0.084	0.090	0.093	0.094	0.091	0.079
		M^+	0.027	0.029	0.030	0.031	0.032	0.032	0.032	0.029
	Short side α_{sx}	M^-	0.063	0.074	0.084	0.093	0.099	0.104	0.112	0.118
		M^+	0.027	0.032	0.037	0.041	0.045	0.049	0.054	0.059
	Long side α_{sy}	M^-	0.063	0.061	0.059	0.055	0.051	0.046	0.039	0.029
		M^+	0.027	0.027	0.026	0.025	0.023	0.022	0.019	0.015
	Short side α_{sx}	M^-	0.056	0.062	0.067	0.071	0.074	0.076	0.079	0.081
		M^+	0.023	0.026	0.028	0.031	0.032	0.034	0.036	0.038
	Long side α_{sy}	M^-	0.042	0.039	0.035	0.032	0.028	0.025	0.020	0.015
		M^+	0.020	0.019	0.017	0.016	0.014	0.013	0.011	0.008
	Short side α_{sx}	M^-	0.042	0.053	0.064	0.073	0.081	0.089	0.101	0.111
		M^+	0.020	0.025	0.030	0.035	0.038	0.043	0.049	0.056
	Long side α_{sy}	M^-	0.056	0.058	0.059	0.058	0.057	0.054	0.047	0.037
		M^+	0.023	0.023	0.023	0.023	0.023	0.022	0.019	0.016
	Short side α_{sx}	M^-	0.042	0.050	0.056	0.062	0.066	0.070	0.074	0.078
		M^+	0.018	0.021	0.024	0.027	0.029	0.031	0.034	0.037
	Long side α_{sy}	M^-	0.042	0.041	0.039	0.037	0.034	0.031	0.026	0.020
		M^+	0.018	0.018	0.017	0.016	0.015	0.013	0.012	0.009

Msx=αsx*η*lx2 e

May= αsy* η*lx2

$M_{ay} = \alpha_{sy} * \eta * lx^2$



appendix 4. Bill of quantities

Ground floor					
SN	Description	Unit	Quantity	Rate/rwf	Total
I	**Setting out**				
1.1	site clearance				
1.1.1	Strip and excavate soft, vegetable top soil not exceeding deep	m^3	1200	3700	4,440,000
	s/total I				**4,440,000**
ii	**Foundation and excavation**				
1	Trench excavation	m^3	250	2700	675,000
2	Excavation of footing	m^3	350	2700	945,000
3	Base concrete	m^2	450	7000	3,150,000
4	Foundation masonry joined by cement mortar	m^3	250	55,000	13,750,000
5	Cap on foundation	m^2	450	7000	3,150,000
6	Damp proof	m^2	450	5000	2,250,000
7	Back filling	m^3	200	2500	500,000
	s/total II				**24,420,000**
III	**Concrete**				
1	Blinding concrete	m^2	450	7000	3,150,000
2	For footing	m^3	80	380,000	30,000,000
3	For sub column	m^3	8	380,000	3,000,000
4	For tie beam	m^3	24	380,000	9,120,000
5	For column	m^3	15	380,000	5,700,000
6	For beam	m^3	60	380,000	22,800,000
7	For slab	m^3	160	380,000	60,800,000

8	For stair and lamp	m^3	8	380,000	1,900,000
	s/total III				**136,470,000**
IV	**ELEVATION**				
1	Elevation of walls in burnt brick	m^3	350	60,000	21,000,000
2	Shuttering glass	m^2	10	40,000	400,000
	S/total IV				**21,400,000**
V	**DOORS AND WINDOW**				
1	Simple Door Type 90*210	Pcs	24	150,000	3,600,000
2	Double Doors 250*210	Pcs	2	200,000	400,000
3	Window Of 90*50	Pcs	13	60,000	780,000
4	Double Window 180*180	Pcs	22	180,000	3,960,000
	S/TOTAL V				**8,740,000**
V	**PLASTERING**				
1	Hardcore filling to under walkways and ground floor slab	m^3	450	4000	1,800,000
2	Sand and cement mortar rendering to slab soffit (ceiling)	m^2	850	2500	2,125,000
3	Sand and cement mortar rendering to the wall	m^2	1250	3000	3,250,000
	S/TOTAL VI				**7,175,000**
VII	**PAINTING**				
1	Painting of walls, columns, and beams	m^2	3300	3500	11,550,000

	(double side)				
2	Painting of door and Window	m^2	220	2500	550,000
VIII	**FLOOR FINISER**				
	S/TOTAL VII				**12,100,000**
VIII	**SANITARY DETAIL**				
1	Urinals	pcs	5	65,000	325,000
2	wash hand basin	pcs	10	85,000	850,000
3	Toilet	pcs	16	120,000	1,920,000
	S/TOTAL				**3,095,000**
IX	**ELECTRICAL INSTALATION**				
1	Electrical cables and conduits	FF	1.00	5,500,000	5,500,000
2	Socket	PCS	85	15,000	1,275,000
	S/TOTAL IX				**6,775,000**
GROUND FLOOR TOTAL					**224,615,000**
FIRST FLOOR					
SN	**DESCRIPTION**	**UNITY**	**QUANTITY**	**RETE/RWF**	**TOTAL**
	SUPERSTRUCTURE				
I	**CONCRETE**				
1	reinforced concrete column	m^3	15	380,000	5,700,000
2	Reinforced concrete beam	m^3	60	380,000	22,800,000
3	Reinforced concrete staircases and lamp	m^3	8	380,000	3,040,000

4	Reinforced concrete slab	m^3	160	380,000	60,800,000
	S/TOTAL I				**92,340,000**
II	**ELEVATION**				
1	Elevation of the walls in burnt bricks	m^3	360	60,000	21,600,000
2	Shuttering glass	m^2	25	40,000	1,000,000
	S/TOTAL II				**22,600,000**
III	**DOORS AND WINDOW**				
1	Simple Door Type 90*210	PCS	24	150,000	3,600,000
2	Double Doors 250*210	Pcs	1	200,000	200,000
3	Window Of 90*50	Pcs	13	60,000	780,000
4	Double Window 180*180	Pcs	22	180,000	3,960,000
	S/TOTAL III				**8,540,000**
IV	**PLASTERING**				
1	Sand and cement mortar rendering to the wall	m^2	1540	4000	6,160,000
2	Sand and cement mortar rendering to slab soffit (ceiling)	m^2	1050	2500	2,625,000
	S/TOTAL IV				**8,785,000**
V	**PAINTING**				
1	Painting of walls, columns, and beams (double side)	m^2	1540	3,500	5,390,000
2	Painting of doors, and	L	20	2,500	50,000

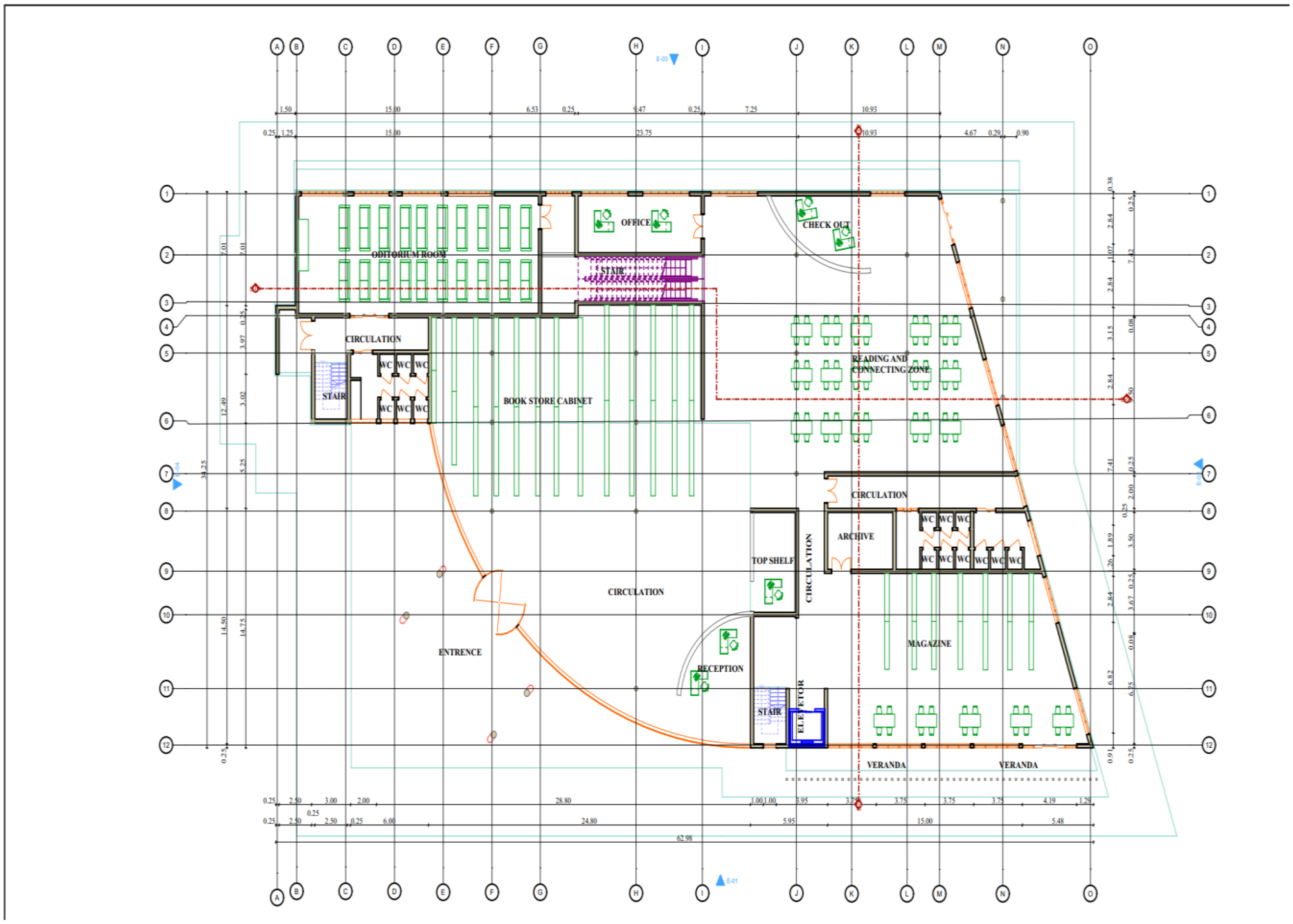
	Windows				
	S/TOTAL V				**5,440,000**
VI	**SANITARY DETAILS**				
1	Urinals	pcs	5	65,000	325,000
2	wash hand basin	pcs	14	85,000	1,190,000
3	Toilet	pcs	16	120,000	1,920,000
	S/TOTAL VII				**3,435,000**
VII	**ELECTRICAL INSTALATION**				
1	Electrical cables and conduits and socket	FF	1.00	5,500,000	5,500,000
	S/TOTAL VII				**5,500,000**
FIRST FLOOR TOATAL					**145,860,000**
SECOND FLOOR					
I	**CONCRETE**				
1	reinforced concrete column	m^3	15	380,000	5,700,000
2	Reinforced concrete beam	m^3	60	380,000	22,800,000
3	Reinforced concrete staircases and lamp	m^3	8	380,000	3,040,000
4	Reinforced concrete slab	m^3	160	380,000	60,800,000
	S/TOTAL I				**92,340,000**
II	**ELEVATION**				

1	Elevation of the walls in burnt bricks	m^3	360	60,000	21,600,000
2	Shuttering glass	m^2	25	40,000	1,000,000
	S/TOTAL II				**22,600,000**
III	**DOORS AND WINDOW**				
1	Simple Door Type 90*210	PCS	24	150,000	3,600,000
2	Double Doors 250*210	Pcs	1	200,000	200,000
3	Window Of 90*50	Pcs	13	60,000	780,000
4	Double Window 180*180	Pcs	22	180,000	3,960,000
	S/TOTAL III				**8,540,000**
IV	**PLASTERING**				
1	Sand and cement mortar rendering to the wall	m^2	1250	3000	3,250,000
2	Sand and cement mortar rendering to slab soffit (ceiling)	m^2	1050	2500	2,625,000
S/TOTAL IV					**8,785,000**
V	**PAINTING**				
1	Painting of walls, columns, and beams (double side)	m^2	1540	3,500	5,390,000
2	Painting of doors, and windows	L	20	2,500	50,000
	S/TOTAL V				**5,440,000**

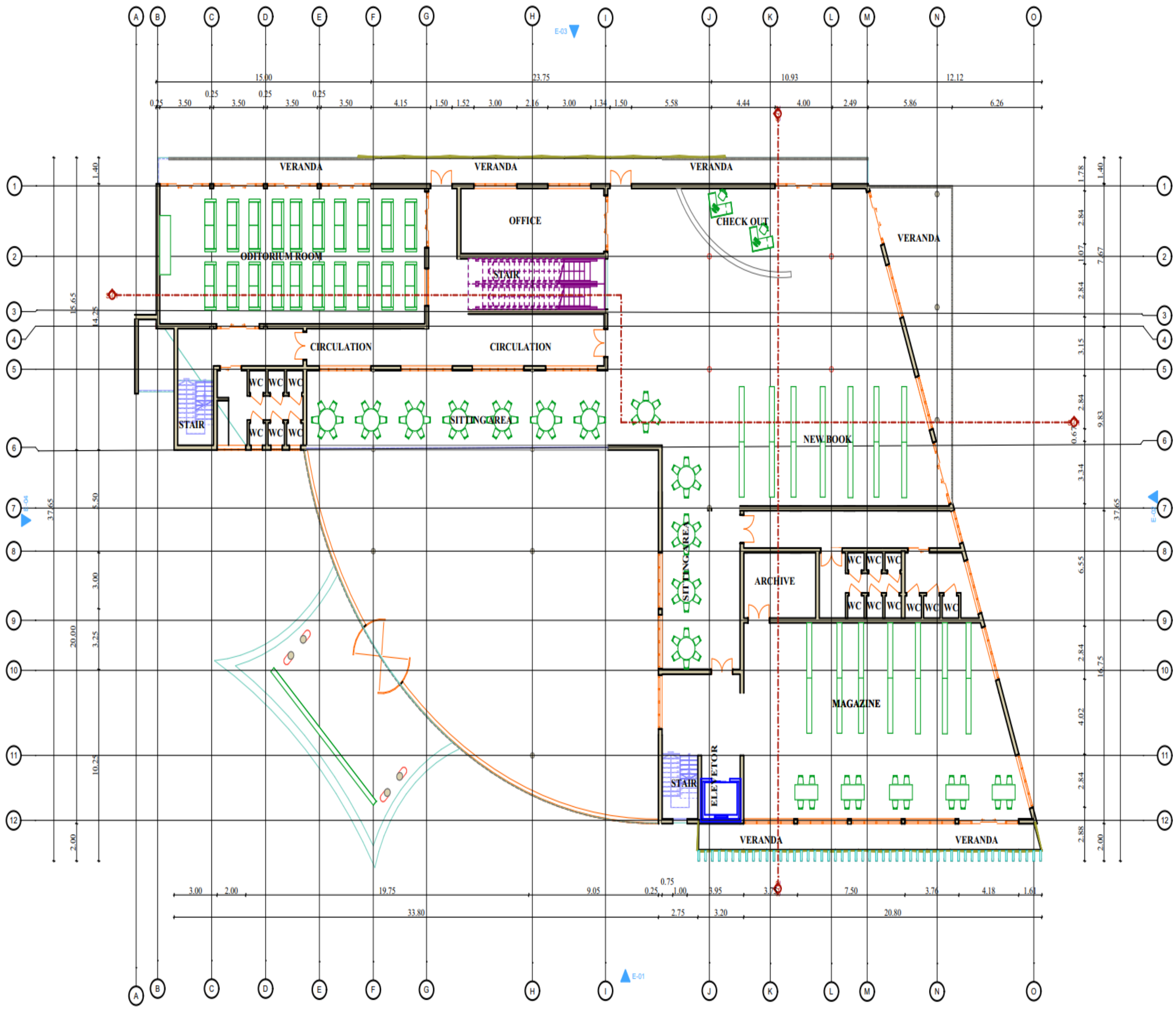
VI	**SANITARY DETAILS**				
1	Urinals	pcs	5	65,000	325,000
2	wash hand basin	pcs	14	85,000	1,190,000
3	Toilet	pcs	16	120,000	1,920,000
	S/TOTAL VII				**3,435,000**
VII	**ELECTRICAL INSTALATION**				
1	Electrical cables and conduits and socket	FF	1.00	5,500,000	5,500,000
	S/TOTAL VII				**5,500,000**
SECOND FLOOR TOTAL					**145,860,000**
THIRD FLOOR					
	SUPERSTRUCTURE				
I	**CONCRETE**				
1	reinforced concrete column	m^3	18	380,000	6,840,000
2	Reinforced concrete beam	m^3	60	380,000	22,800,000
3	Reinforced concrete staircases and lamp	m^3	8	380,000	3,040,000
4	Reinforced concrete slab	m^3	160	380,000	60,800,000
	S/TOTAL I				**93,480,000**
II	**ELEVATION**				
1	Elevation of the walls in burnt bricks	m^3	380	60,000	22,800,000
2	Shuttering glass	m^2	25	40,000	1,000,000
	S/TOTAL II				**22,800,000**

III	**DOORS AND WINDOW**				
1	Simple Door Type 90*210	PCS	24	150,000	3,600,000
2	Double Doors 250*210	Pcs	1	200,000	200,000
3	Window Of 90*50	Pcs	13	60,000	780,000
4	Double Window 180*180	Pcs	22	180,000	3,960,000
	S/TOTAL III				**8,540,000**
IV	**PLASTERING**				
1	Sand and cement mortar rendering to the wall	m^2	1250	3000	3,250,000
2	Sand and cement mortar rendering to slab soffit (ceiling)	m^2	1050	2500	2,625,000
	S/TOTAL IV				**8,785,000**
V	**PAINTING**				
1	Painting of walls, columns, and beams (double side)	m^2	1800	3,500	6,300,000
2	Painting of doors, and Windows	L	20	2,500	50,000
	S/TOTAL V				**6,350,000**
VI	**SANITARY DETAILS**				
1	Urinals	pcs	5	65,000	325,000
2	wash hand basin	pcs	14	85,000	1,190,000
3	Toilet	pcs	16	120,000	1,920,000

4	bath tube	pcs	14	150,000	2,100,000
	S/TOTAL				**5,515,000**
THIRD FLOOR TOTAL					**145,470,000**
TOTAL FLOOR(Ground+ 1st+ 2nd+ 3rd)					
GENERAL TOTAL					**661,805,000**
1	Purchase and electrical installation	Ff	1.00	25,000,000	25,000,000
2	Purchase and installation of protection against fire	Ff	1.00	5,000,000	5,000,000
3	Purchase and installation of networking and thermal insulation and sound proof	Ff	1.00	52,000,000	52,000,000
TOTAL					82,000,000
TOTAL OF ALL FLOORS AND VARIOUS SUPPLIES AND FACILITIES					**713,805,000**
CONTIGENCIES 5%					**35,690,000**
GENERAL TOTAL					**750,500,000**

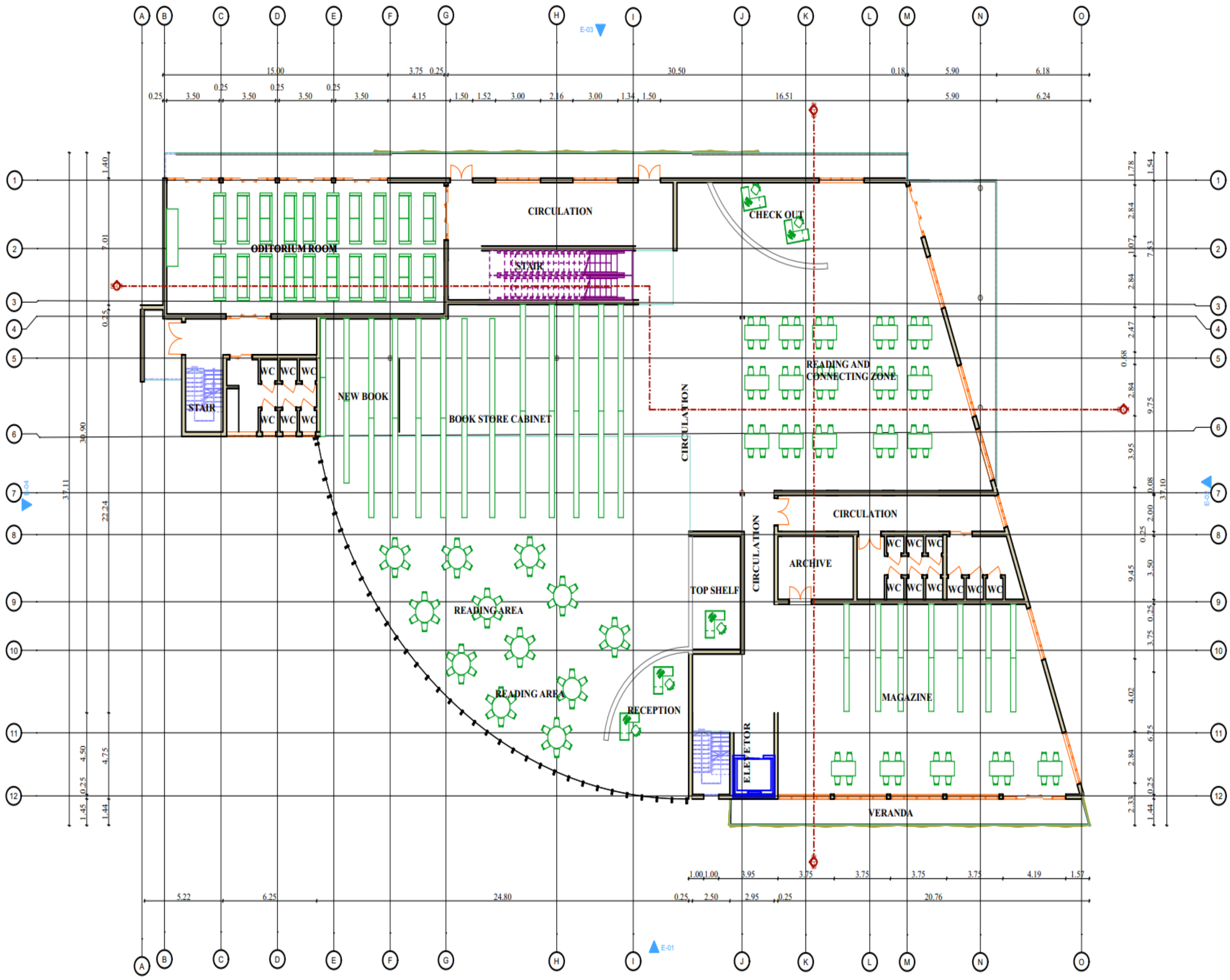


Apendix 5. Structural plan

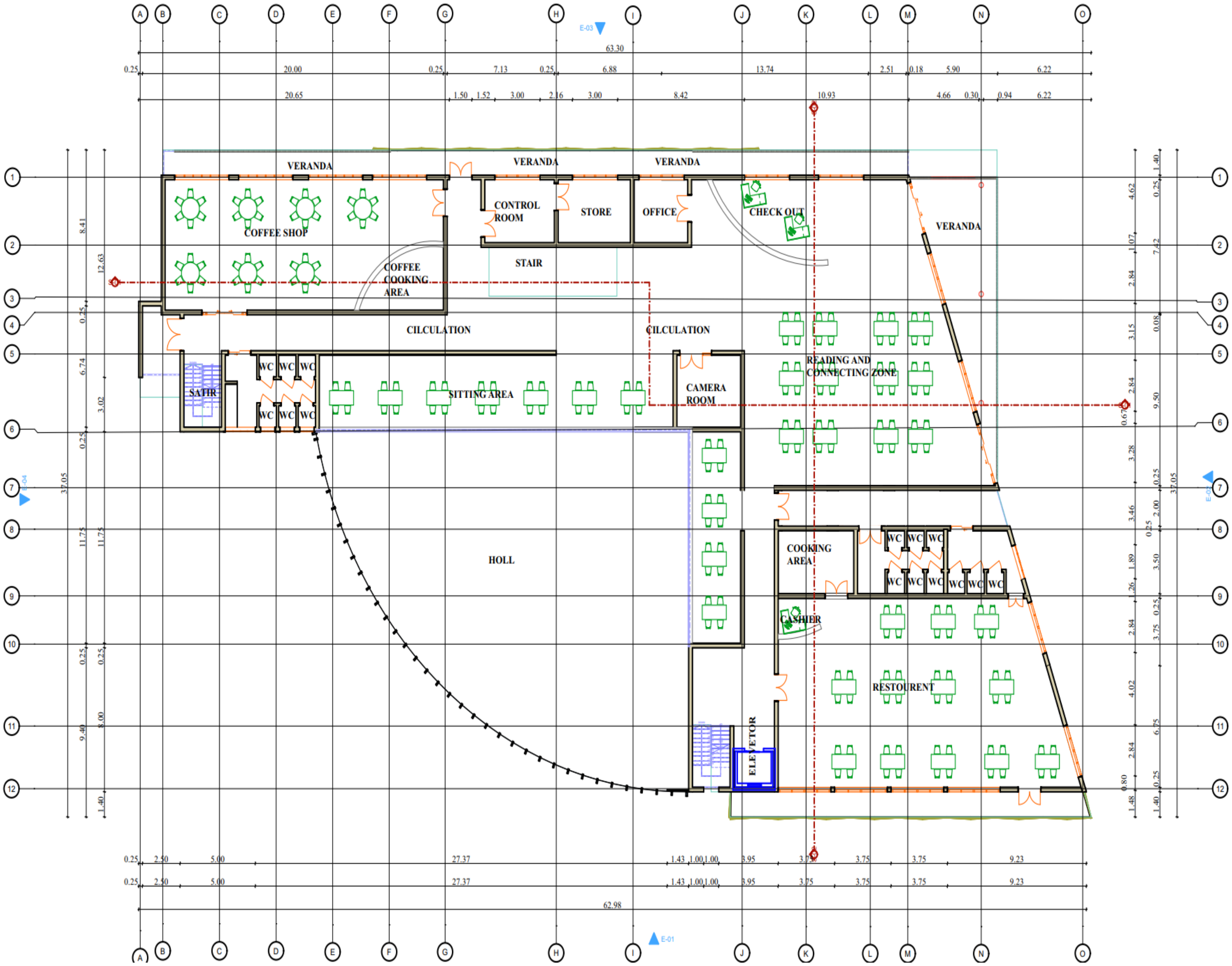


Apendix 6. First, second, third floor plan

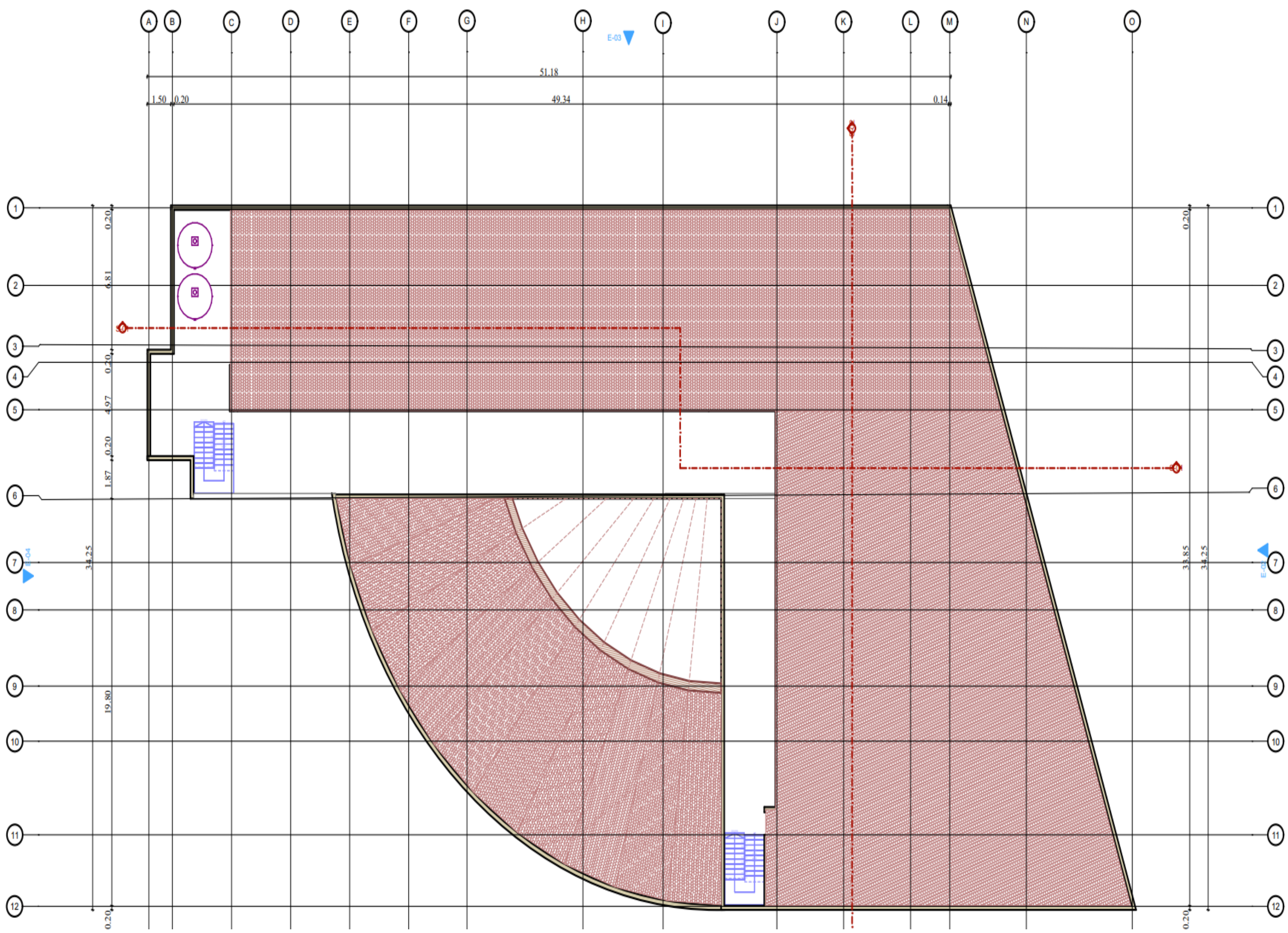
Apendix 7.second floor



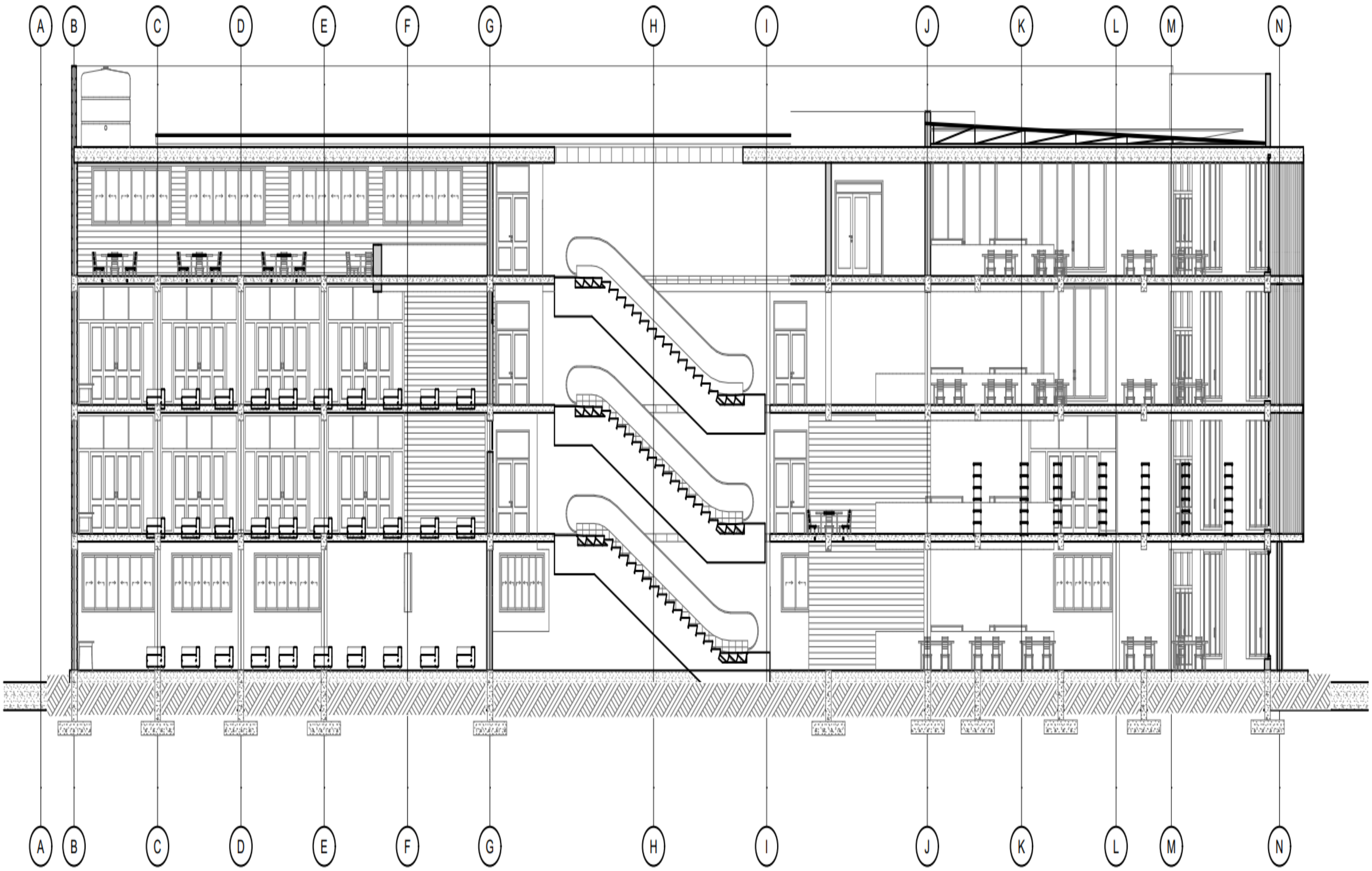
Apendix8.third floor



Apendix 9 Roof plan

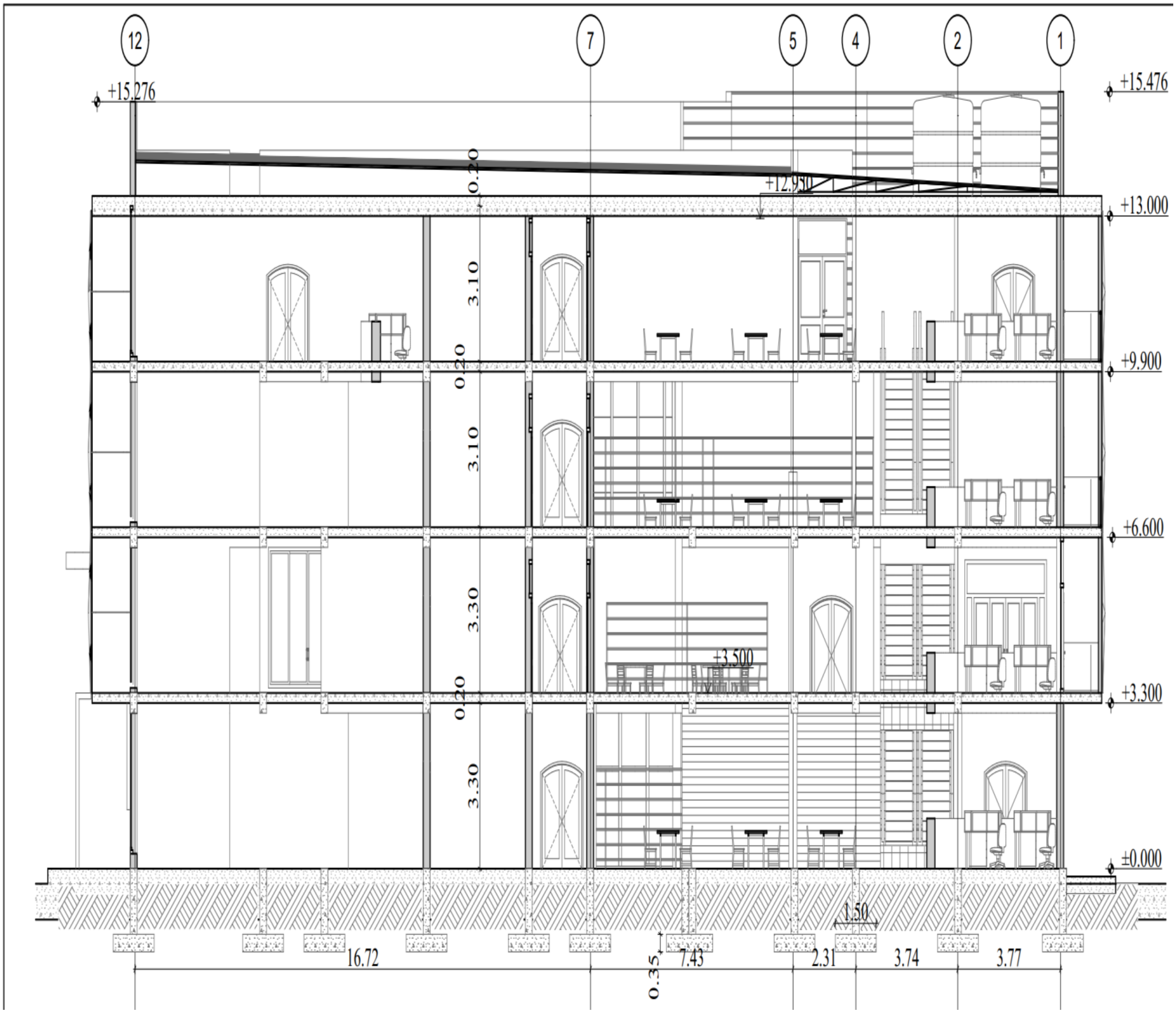


Apendix 10 cross section



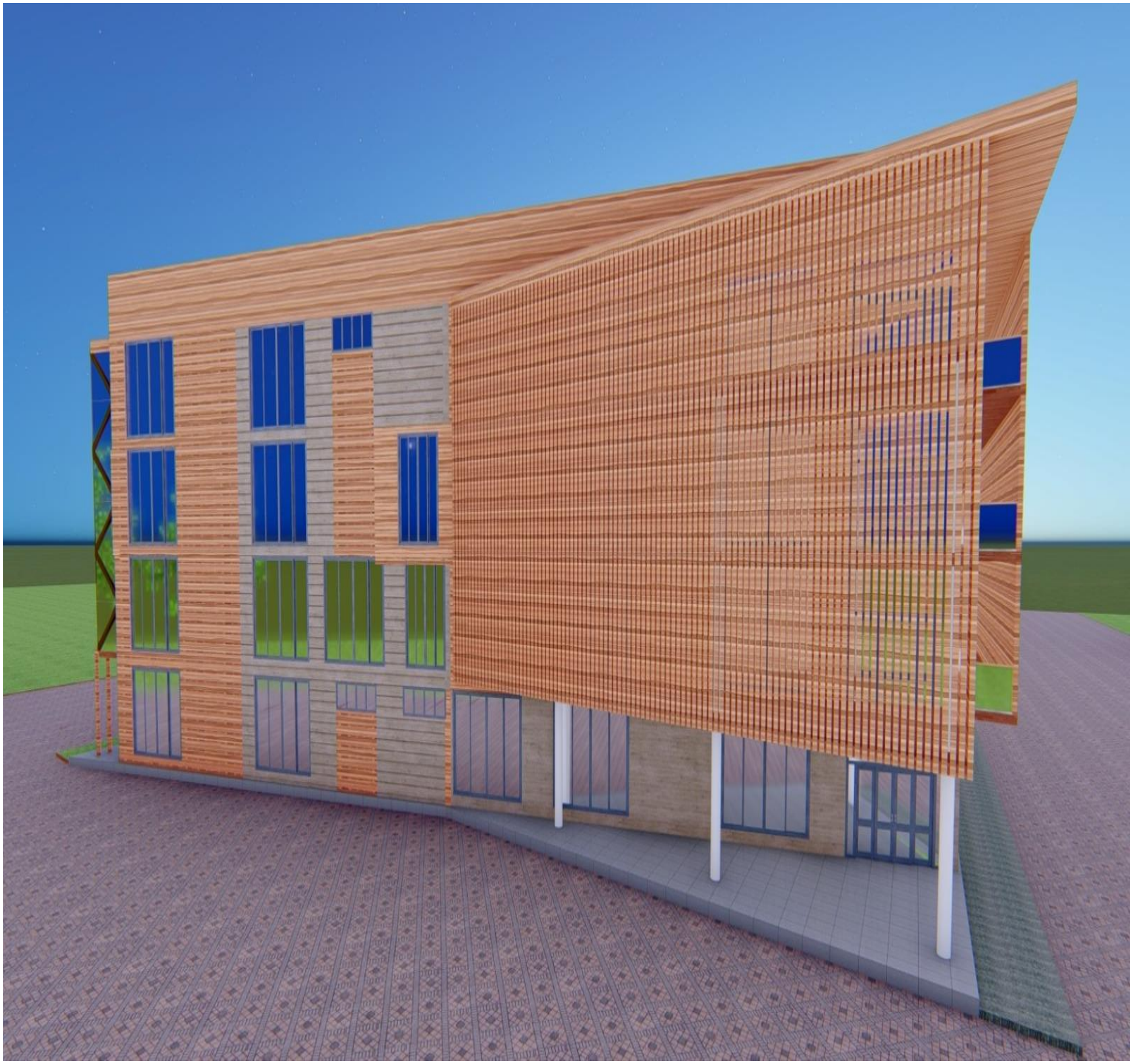
Section 1-1

Apendix11 longitudinal section



Apendix12 front view

Apendix 13 right view



Apendix 13 left view

Apendix 14 back view