ULK POLYTECHNIC INSTITUTE (ULK)

DEPARTMENT OF CIVIL ENGINEERING

OPTION: CONSTRUCTION TECHNOLOGY

ACADEMIC YEAR: 2023-2024

STRUCTURAL DESIGN OF A FIVE STOREY MODERN MARKET BUILDING

CASE STUDY: KIREHE , MAHAMA SECTOR

Submitted in partial fulfillment of the requirements for the award of an advanced diploma in Construction Technology.

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Kigali, September 2024

DECLARATION

I declare that the 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 fulfillment of the award of an Advanced Diploma with honors in Civil Engineering at Ulk Polytechnic institute.

The candidate's name: Ndagijimana Pilote

Signature of the candidate: …………………………………………

Date of submission: ………………………………

APPROVAL

This is to certify that this dissertation work entitled "Structural design of a five stories Modern Market building in Kirehe district" is an original study conducted by Ndagijimana Pilote under my supervision and guidance.

The supervisor's name: Eng. Bonaventure Nkiranuye

Signature of the supervisor ……………………………………………

Submission date ………………… …………………………………….

DEDICATION

This research project is dedicated to:

My Mother and Siblings

My Sponsor Maison Shalom

Almighty God

All my colleaguesAll friends

All my esteemed Lecturers

ACKNOWLEDGEMENTS

The success of this research would hardly be achieved without the help and guidance from individuals and institutions. It is not however easy to mention each and everyone’s name but the following deserve mention. First and fore most I thank the Almighty God for empowering me during my study up to the completion of my Advanced diploma degree in Civil Engineering with his abundant blessings, guidance and strength to go through my studies.

I also express my gratitude to Ulk polytechnic institute Administrators and all lecturers. My special appreciations go to my supervisor Eng. Bonaventure Nkiranuye.

Who devoted his precious time to direct this research work, despite his other huge commitments and responsibilities, and have kindly accepted to supervise this research. His excellence guidance and experience has been valuable to the success of this research. A cordial gratitude is addressed to my family members and my sponsors Maison shalom for their care, advices, moral and financial support. Thanks go to my classmates and all my friends for their comprehension and knowledge we shared from the beginning of our studies.

I feel thankful to the staff of Kigali Independent University Especially Polytechnic institute, through the faculty of Construction and Technology in the Department of Civil Engineering for making available an excellent environment for following my studies and for helping me acquire appropriate knowledge that has brought fruition.

ABSTRACT

This research seeks to fill this gap by suggesting construction of a five-story building as a modern market facility in the Mahama sector of Kirehe District. The old-fashioned markets, Kabeza and Munini, cannot meet the increasing customers, and continues to increase as demand rises. This study was carried out in order to prove this hypothesis and offer adequate technical solutions for the construction of the new market building.

The other methods adopted in the study include analytical methods in the designing of structural parts like slabs, beams, columns, and also their supporting base-kinds of foundation, staircases and ramps. The software programs were ArchiCAD 24 for Plan, Sections, Elevation, Perspective and other architectural drawings, etabs for structural analysis and manual beam design calculations with reinforcement detailing. ArcGIS and Google earth were included for the mapping and positioning of the study area. This building consists of a five story Modern market building which located in Eastern province Kirehe district Mahama sector, it has 27rooms each floor and ground floor aredimensioned of 3438cm*4136 and first floor up to five floors are the same dimension of 3230cm*3930cm. It has a five story where from the ground floor to the five floors is for market purposes.

The results showed that the designed steel reinforcements to be arranged in slab were 6bars of 12mm of diameter at the top 6Φ12mm and 4Φ12mm at the bottom while for T beam designed steel reinforcements were 4Φ12mm at the top and 4Φ14mm at the bottom another L beam designed steel reinforcement were 4Φ12mm at the top and 3Φ14mm at the bottom. And for column the designed steel reinforcement was 4Φ20mm for ground floor part the column and 4Φ12mm for first floor, second, third, fourth and fifth floor designed steel reinforcement were 4Φ12mm while foundation steel designed by Prokon software that shows reinforcement were 6Φ20mm for the stair designed steel reinforcement were 2Φ10mm/m for main and 2Φ12mm a ramp design steel reinforcement was 6Φ10mm.

The findings of the study are essential for this modern multi storied market building construction project in Mahama as they enhance the poor market infrastructure available now and promote economic progress within the area.

Key words: Structural design, reinforced concrete building, geotechnical study, Description of Modern Market Infrastructure

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LIST OF SYMBOLS AND ABBREVIATIONS

a: width of column

Ab: Cross section area of the column

Ab: is average lateral area of the punching pyramid

Ab: The area of the column cross section

ac: width of column

af: width of footing

As: Total cross section of steel reinforcement

As_{max}: Maximum bending moment (at the top and bottom)

b: The width of the compressive area

bc: breadth of the column

bf: breadth of footing **bf**: flange of the beam**bw**: web of the beam

d: short distance of the beam

Def max: Defection maximum**F**: fixed support

Fcu: the characteristic concrete cube strength.

F_u: The ultimate deflection

Fy: is the characteristic strength of reinforcements

Fy: vertical force acts on the support of ramp

Fyv: is the characteristic strength of link reinforcements

G : (Going or tread) **GK**: Permanent loads**h**: height of the beam**H**: Height of column **H**: Rise

he: Effective height

Hf: Height of footing

hf: Thickness of the slab

ho: Effective height

lc: Difference of the distance between half of breadth and half of breadth of the column

lx: Length of the short side of the panel**ly**: Length of the long side of the panel**Mx^-, My^-**: Bending moment at the top

Mx^+, My^+: Bending moment at the bottom

N: Total loads of slab

Nc: loads from the column

Nf: Load transmitted by the column to the foundation

No: numeric number

P: Design pressure

Q: shear force acting on the cross section

Qf: Punching shear force

QK: Live loads

Rb: Design concrete compression strength

Rbt: Concrete design tensile strength

Rs: Design steel tensile stress

Rsc: Area of steel compressive strength

s: Distance between stirrup **Um**: average perimeter **Vmax**: Maximum shear force

αm, η : coefficient related to the design of members subjected to bending moment

αsx : Long side of the panel

αsy: short side of the panel

Δl: Difference between long span and short span of the beam

Δq:balancing shear force

Φ: Diameter of steel reinforcement expressed in (mm)

y: unite weight

λ: Ratio chooses the type of panel

λ: Slenderness ratio

ξ: The ratio between the effective depth of concrete compressive zone and the effectivedepth of the cross section.

ξR: the maximum value of ξ

φ: Coefficient used to take into account the column slenderness and the constructioninaccuracies.

ULK: Université Libre de Kigali

LIST OF APPENDICES

CHAPTER 1: GENERAL INTRODUCTION

1.1. Introduction

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

1.2. Background of the study

In worldwide like urbanization and densification where a global trend towards urbanization has driven the need for high-rise buildings, including five-story structures, in major cities to accommodate growing populations and optimize land use (world bank, 2018).

Also, mixed-use developments where five-story buildings are often seen as a good fit for mixed-use developments, combining residential units, commercial spaces, and parking within a single structure (un habitat, 2020).

In east Africa a rapidly growing economies and urbanizing populations are creating a demand for more housing and commercial space, with five-story buildings increasingly becoming a viable option (world bank, 2023). Also, the improvements in infrastructure like transportation networks and construction capabilities are making the construction of taller buildings more feasible in some east African cities (African development bank, 2021).

In Kigali, Rwanda's capital city, is experiencing rapid urbanization. five-story buildings are increasingly seen in the city center to accommodate growing commercial and residential needs while promoting efficient land use (city of Kigali, 2022). The Rwandan government has implemented initiatives to encourage sustainable and identified urban development, potentially making five-story buildings a more common sight in the future (World Bank, 2021).

1.3. Problem statement

Overpopulation is a term that has not been quite attributed in detail to Kirehe District and the Mahama refugee camp and its surrounding areas has contextually warranted other researches desterilization of the camp has contextually warranted other researches. Thus, the aim of the study: The Influence of Refugees' Settlements on Land Cover' (IJAEM, 2021) is to understand those of the camp. One of the issues raised in the camp has provided extreme environmental concern as refugees are blamed for the increasing utilizations of natural resources, the deforestation for example, as a result of the desire of the refugees for firewood, and its consequences could be population pressure.

In yet another academic pursuit, "The Influence of Refugee Camps on Surrounding Communities in Developing Economies" (Kalu Institute, 2021), focuses on the impact of the camp on the host population from social and economic perspectives. The report also states such people are involved in cash-out activities that require them to buy raw materials and supplies from local markets. Though this type of economic relationship has positive effects it can also create further pressure on the already constrained resources in the highly densely populated area.

There are difficulties with regard to accessing agricultural products within Mahama-residents. The available structures have been constructed many years ago hence do not conform to the present-day requirements of new construction with such large footprints emblazoning unnecessary strife for land space. Such inadequacy is such that aside from the existing structure not being able to cater for the needs of the ever-increasing population, the market in these areas is poorly run.

Furthermore, the lack of a well-organized market environment deters potential investors. To address these issues, a multi-story modern market building has been proposed as a solution. This approach aims to improve the efficiency of market operations by reducing land usage and slum conditions associated with current market setups. It is anticipated that this development will enhance the attractiveness of the region for both local residents and foreign investors, contributing to a more effective and appealing commercial environment in Kirehe.

1.4 objectives of the study

1.4.1. Main objective

The main objective of this project is to do the structural design of five story modern market building.

1.4.2 Specific objectives

The specific objectives of this project were:

1. To prepare floor plans, sections, elevations, site plans and perspectives
2. To investigate the bearing capacity of the soil.
3. To design the columns, beams, slab and stairs
4. To estimate the cost of construction works.

1.5 significance of the study

1.5.1. Personnel benefits

It is a normal practice for the final year students at Ulk Polytechnic institute to work on a project related to ourstudies. The personal interest of the student in the subject of this research is also our devotion to participate in the sustainable development of our country.

This project allowed me to be familiarized with planning, design and analysis of structures for civil engineering software like ArchiCAD 24, Prokon and Etabs.

1.5.2. Academic benefits

Apart from student a well-executed final year projects showcase the quality of education and the skills students graduate with. This can enhance the school's reputation and attract potential students seeking a program that emphasizes real-world application. also, the project supervision process allows faculty members to demonstrate their expertise and guidance in specific areas of study. this can contribute to a positive perception of the school's faculty and the program's depth.

Projects can foster a culture of innovation and research within the school. Investigating new ideas and contributing to knowledge in a particular field can enhance the school's reputation for cutting-edge education. Certain projects might involve collaboration with external organizations, fostering industry partnerships and potentially leading to internship or job opportunities for future graduates

1.5.3. Socio-economic benefits

Rwanda is a developing country which is struggling to improve everything, even thoughit is small but the land has to be well managed. this why a multistoried modern market building project was chosen so that the knowledge and skills gained final year can be used to solve the problem of land management and help people meeting their needs easily and government will find a good manner of tax correction as well as policy of RRA says about to increase capacity and to achieve on their goals.

1.6 Scope and limitation of the study

This project of design and analysis of five story building which will serve as modern market building was focused on structural design only due to time and financial problems, which means that electrical, mechanical, plumbing works and cost estimation will not be discussed in this project.

1.7 organization of the study

This project is made up of five chapters where:

Chapter one: General introduction includes background of the study, problem statement, objectives, significance of the project, justification and delimitation of the project,

Chapter two: Literature review deals the literature review will include theories concerning architectural design. Structuralanalysis and cost estimation from books, the internet

Chapter three: this includes Materials and methods, Methodology will give information about location of site, different techniques applied to obtain information and data required and structural design methods and materials to be used.

Chapter four: Results and discussion will deal with result of structural design. Structure analysis calculations and discussion about the results and Chapter five: conclusions and recommendations will state the output of the project and give some suggestions.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The design of five-story apartments structures includes aspects that are critical to ensuring safety, functionality, and also sustainability. This section seeks to systematically analyze various factors that have been provided in the literature regarding the structural design, problems, and new ideas associated especially with multi-story constructions. Thus, this review seeks to provide an additional dimension regarding the design of five-story apartment buildings through studying the theories, practices, and trends that have emerged.

2.1.1. Definition of multi-story building

As the name suggests “multi story housing,” the term implies the erecting of residential complexes having more than one floor with emphasis on horizontal and vertical occupancy patterns. Such types of buildings in general are raised in a number of levels such that the upper and lower levels contain either residential or business occupancy spaces. The term meaning “multi-story” that the term is used in construction refers to any building with a minimum rib or three occupancy/rise stores however, this may depend on the area building codes and classifications.

When standing geometry as an architectural term describes a vertical arranging of the compartments multiple-story buildings bearing walls as a basement wall. These structures are designed with Wall the Structural frame Mandalay crossing timely deliver wall the built up the first level of the vaulted roof.

In accordance with the definition proposed by the American national standards institute, a high-rise building is a structure of eleven stories and above but this height may vary in other countries and in another n, g. – The industrial structural cement goods centers society of construction engineers. Multi-story buildings often have protective measures such as use of fireproofing materials, means for emergency egress, structure reinforcement for super loading and other diverse risks related to tall buildings (Fisher & Bostwick, 2010).

The evolution of multi-story buildings has been closely linked to advancements in engineering and materials science. The earliest examples of multi-story structures date back to ancient civilizations, but the modern conception of high-rise buildings began with the development of steel-frame construction in the late 19th century (Fazio, Moffett, & Wodehouse, 2008).

In contemporary architecture and structural design, multi-story buildings are often designed with considerations for environmental sustainability, energy efficiency, and urban density. Recent research emphasizes the importance of integrating green building practices and advanced engineering solutions to enhance the performance and sustainability of these structures (Kibert, 2016).

2.1.2. Building services

Building services, also known as building systems or MEP (Mechanical, Electrical, and Plumbing) systems, encompass the various systems and technologies integrated into a building to ensure its functionality, comfort, and safety. These services are crucial for the effective operation of modern buildings and include a range of systems that provide essential functions such as heating, ventilation, air conditioning (HVAC), electrical power, lighting, water supply, and waste management.

Building services refer to the range of systems installed within a building to support its operational needs and enhance the occupants' experience. These systems include:

- **Mechanical Systems**: Heating, ventilation, and air conditioning (HVAC) systems that regulate indoor climate and air quality (Jones, 2016).
- **Electrical Systems**: Power distribution, lighting, and communication systems that provide electrical energy and connectivity (Hughes & Griffiths, 2014).
- **Plumbing Systems**: Water supply, drainage, and waste management systems that handle the building's water-related needs (Smith, 2018).

Building services are integral to the functionality and efficiency of a building. They contribute to the comfort, health, and safety of occupants by ensuring proper temperature regulation, air quality, and access to essential utilities. Efficient building services also play a significant role in energy management and sustainability efforts (CIBSE, 2019).

Advances in building services technology have led to significant improvements in energy efficiency and sustainability. Recent research emphasizes the integration of smart building technologies, such as automated HVAC systems and energy management systems, to enhance performance and reduce operational costs (Kovac & Kolar, 2020). Additionally, the use of renewable energy sources and water-saving technologies has become increasingly prevalent in modern building design (Bordass & Leaman, 2019).

The design and implementation of building services face various challenges, including the need for interoperability among systems, ongoing maintenance, and adaptation to evolving standards and regulations. Future research is focused on developing more integrated and adaptive building service systems that can respond dynamically to changing conditions and user needs (Zhao & Li, 2021).

2.1.3. Architectural design

Architectural design involves the planning, designing, and construction of form, space, and ambiance in ways that reflect a balance between functional, technical, social, environmental, and aesthetic considerations. A well-executed architectural design should be accessible, aesthetically pleasing, cost-effective, functional, productive, safe or secure, and sustainable (McGuire & Schaffer, 2021).

The concept of architectural design centers around the arrangement and relationship of the components or elements that make up a structure. Typically, an architect is responsible for overseeing this process, working with space and design elements to create a unified, coherent, and functional building (McGuire & Schaffer, 2021). Architectural design focuses on the aesthetic and function of the structure. Its design works to create, what is involved in the design process, the steps are as follows: architectural design focuses on the aesthetic and function of the structure. Its design works to create, what is involved in the design process, the steps are as follows:

2.1.3.1. Schematic design

Schematic design the first step of the design phase is the schematic design. The schematic design is where the architect gathers information on the needs, style, andwants for the project and from there he will create two to three design options for the client to review. (Pressman, A.2018)

2.1.3.2. Design development

In the design development, the architect will take the schematic designs and developthem to an approved design concept. Any changes the client wants to make to the design should be communicated to the architect during this phase. (Brock, L., & Brown, J. 2021).

2.1.3.3.Construction documents

Construction documents are given to a contractor for the construction of your project.An architect will put together drawings with a lot of detail on them for the contractorsto follow when building. (Kalinowski, E. 2020).

2.1.3.4. Bidding

Bidding is when the architect or client seeks a contractor for their project. They bid the job to the contractor by giving them bid documents which display details of the project. These documents include construction documents and technical specifications. (Demkin, J. A. Ed.2021)

2.1.3.5. Construction

Construction begins once you've found a contractor you like, and you've settled on a design concept that fits your needs. Your architect will be in contact with your contractor throughout the duration of the construction phase to ensure that your projectis being built according to the plans (Levy, S. M.2018).

2.2. Structural design

2.2.1. Definition

Structural design is the methodical investigation of the stability, strength and rigidity of structures. The basic objective in structural analysis and design is to produce a structure capable of resisting all applied loads without failure during its intended life. The primary purpose of a structure is to transmit or support loads. If the structure is improperly designed or fabricated, or if the actual applied loads exceed the design specifications, the device will probably fail to perform its intended function, with possible serious consequences. A well engineer structure greatly minimizes the possibility of costly failures. (McCormac, J. C., & Brown, R. H. 2020)

2.2.2. Loads and moments

The structural design of any structure first involves establishing the loading and other design condition, which must be supported by the structure and therefore must be considered in its design, this is followed by the analysis and computation of internal grossforces, (thrust, shear, bending moment and twisting moments), as well as stress intensities, strain, deflection and reactions produced by loads, changes in temperature, shrinkage, creep and other design condition, the loads may cause the moment which can be sagging or hogging.(Hibbeler,R. C2018).

Before any calculations, the designer has to determine the way the load or the moment is exerting on the structure; a positive bending moment m, clockwise on the negative face and anti-clockwise on the positive face will cause the upper surface of the beam to become concave and the lower surface convex, for obvious reasons, is called a sagging moment, a negative bending moment will produce a convex upper surface and aconcave at lower surface and is therefore termed as a hogging bending moment (Nilson, A. H.,Darwin, D., & Dolan, C. W.2021).

2.2.3. Limit state design

Limit state method refers to the method which considers the ultimate strength of the material at failure (which is ignored in working stress method) and also assures that the structure is serviceable for its intended period of design. (Arya, C. 2019).

The two principal of limit states are ultimate limit state and serviceability limit states:

2.2.3.1. Ultimate limit state

The ultimate limit state is the design for the safety of a structure and its users by limiting the stress that materials experience. In order to comply with engineering demands for strength and stability under design loads, ultimate limit state must be fulfilled as an established condition (Kostov's & Pavlovic, 2020).

2.2.3.2. Serviceability limit state

The serviceability limit state is the design to ensure a structure is comfortable anduseable. This includes vibrations and deflections (movements), as well as cracking and durability. These are the conditions that are not strength-based but still may render the structure unsuitable for its intended use, for example, it may cause occupant discomfort under routine conditions. Serviceability limit state requirements tend to be less rigid than strength-based limit states as the safety of the structure is not in question. A structure must remain functional for its intended use subject to routine loading in order to satisfy serviceability limit state criterion (Connor & faraji, 2018).

2.3. Analysis of structure

The determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, vehicles, furniture, attire, soil strata, prostheses and biological tissue. Structural analysis employs the fields of applied mechanics, materials science and appliedmathematics to compute a structure's deformations, internal forces, stresses, supportreactions, accelerations, and stability.The results of the analysis are used to verify a Structure's fitness for use, often precluding physical tests. Structural analysis is thus a key part of the engineering design of structures (Rathod & Gunjita, 2019).

2.3.1. Load

Structure member must be designed to support specific loads; loads are those forceswhich a given structure should be proportioned. In general, load may be classified as dead and live or imposed. Loads cause stresses, deformations, and displacements in structures (mac, 2020)

2.3.1.1. Dead load

Dead loads are loads of constant magnitudes and fixed positions that act permanently on structure. Such loads consist of the weights of the structural system itself and of all other material and equipment permanently attached to the structural system. Weights of permanent 1 equipment, such as heating and air-conditioning systems, are usually obtained from the manufacturer (Balliol & Mazzolini, 2019).

2.3.1.2. Live load

Live loads as "those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, snowload, rain load, earthquake load, flood load or dead load." In simple terms, the live load for the floors in a home includes your client (the weight of your client's body and any other bodies in a room), furniture, appliances, and anything else a client puts on the floor (Duggan, 2020).

2.4. Materials in construction

2.4.1. Reinforced concrete

Reinforced concrete is a strong durable building material that can be formed into many varied shapes and sizes ranging from a single rectangular column, to a slender curved dome or shell. Its utility and versatility are achieved by combining the best features of concrete and steel.

Consider some of the widely differing properties of these two Materials that are listed below. It can be seen from this list that the materials are more or less complementary. Thus, when they are combined, the steel is able to provide the tensile strength and probably some of the shear strength while the concrete, strong in compression, protects the steel to give durability and fire resistance (Mosley *et al.*, 2018).

Table 2. 1.indicated different properties of concrete and steel.

No	Strength	Concrete	Steel
1	Strength in tension	Poor	Good
2	Strength in Compression	Good	Good, but slender bars willbuckle
3	Strength in shear	Fair	Good
4	Durability	Good	Corrodes if unprotected
5	Fire resistance	Good	Poor, suffers rapid loss of strength at high temperature

2.5. Composite action

The tensile strength of concrete is only about 10% of its compressive strength. Because of this, nearly all reinforced concrete structures are designed on the assumption that the concrete does not resist any tensile forces, which are transferred by bond between the interfaces of the two materials. Thus, members should be detailed so that the concrete can be well compacted around the reinforcement during construction. In addition, some bars are ribbed or twisted so that there is an extra mechanical grip. In the analysis and design of the composite reinforced concrete section, it is assumed that there is perfect bond, so that the strain in the reinforcement is identical to the strain in the adjacent concrete. The stress -strain curves for steel and concrete are given below:

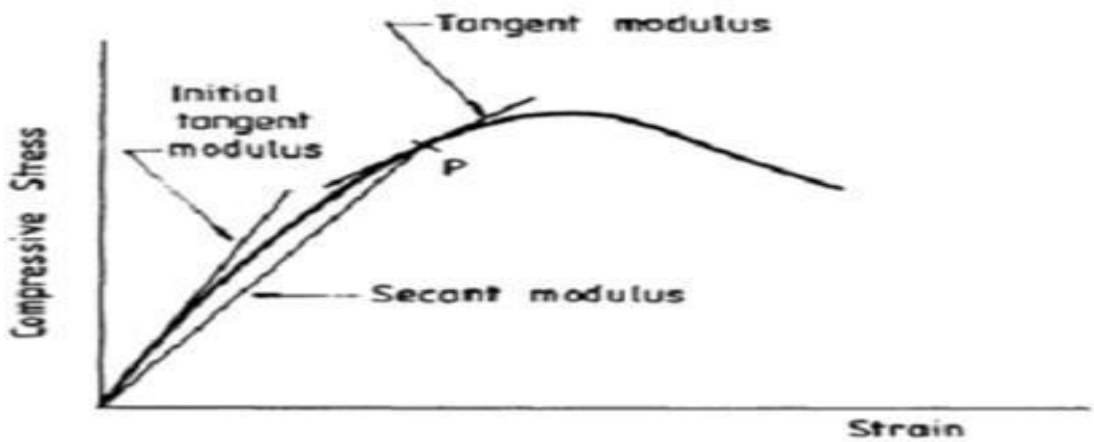

Figure 2.1.Indicated strain curve for concrete (Kosovo s,2018)

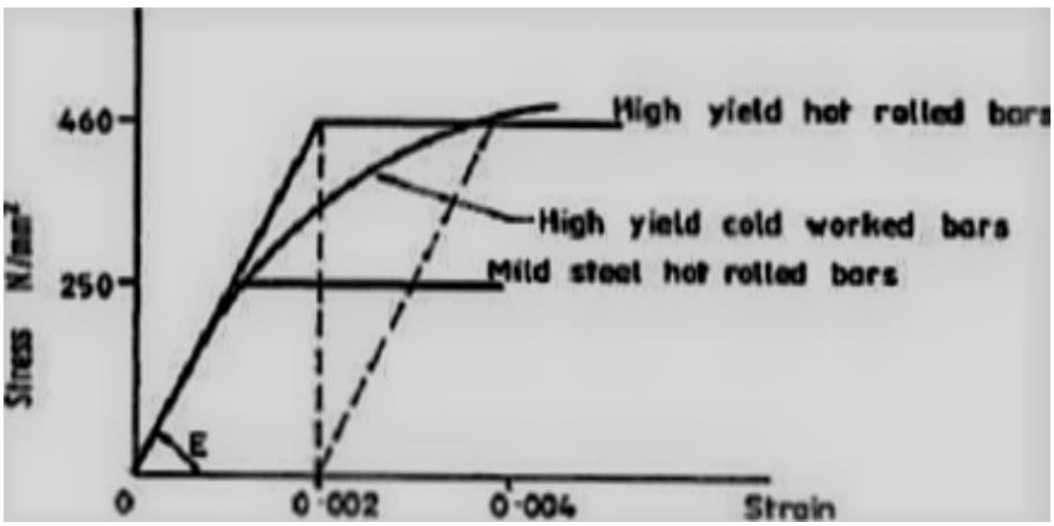

Figure 2.2.Indicated stress-strain curves for reinforcing bars

Concrete is a very variable material, having a wide range of stress-strain curves. A typicalcurve for concrete in compression is shown above. As the load is applied, the ratio between the stresses and strains is almost linear and the concrete behaves like an elastic material with virtually full recovery of displacement if the load is removed.

Eventually, the curve is no longer linear and the concrete behaves like a plastic material, with Incomplete displacement recovery during load removal at this stage. The ultimate strain for most structural concrete tends to be a constant value of approximately 0.0035, irrespective of the strength of concrete *(*Gambhir, *2018).*

2.5.1. Concrete

The selection of the type of concrete is frequently governed by the strength required, which in turn depends on the intensity of loading and the form and size of the structural members. For example, in the lower columns of a multi-storey building a higher-strength concrete may be chosen in preference to greatly increasing the size of the column section with a resultant loss in clear floor space. Concrete of a given strength is identified by its class; a class 25/30 concrete has a characteristic cylinder crushing strength of 25 n/mm2 and cubes strength of 30 n/mm2. The following table shows a list of commonly used classes and also the lowest class appropriate for various types of construction (berthed, 2023).

2.5.1.1. Properties and strength of concrete

2.5.1.1.1. Properties of fresh concrete

The fresh concrete which may be expected to give the best results must possess the property of workability.

This is the most important property of fresh concrete. Workability, in the simplest language, is the ease with which freshly prepared concrete can be transported and placed for the job and compacted to a dense mass. Since workability depends on a number of factors, no single test is thought to be sufficient to express this property of fresh concrete. For quality construction, the following tests are required to be carried out: slump test, compacting factor test (Paik & thayamballi, 2021).

2.5.1.1.2. Properties of hardened concrete

The most important property of hardened concrete is its compressive strength. When we refer to concrete strength, we generally talk about the compressive strength of concrete.

Because concrete is strong in compression but relatively weak in tension and bending. Concrete compressive strength is measured in pounds per square inch (psi). It mostly depends upon amount and type of cement used in concrete mix. It is also affected by the water-cement ratio, mixing method, placing and curing. Concrete tensile strength ranges from 7% to 12% of compressive strength. Both tensile strength and bending strength can be increased by adding reinforcement (Mehta & Monteiro, 2018).

Table 2.2.indicated strength classes of concrete

Class	Lowest class for use as specified
C16/20	Plain concrete
C20/25	Plain concrete
C25/30	Reinforced concrete
C30/37	Prestressed concrete

2.5.2. Reinforcement

2.5.2.1. Water

Water has key role in the production of concrete, it is an important ingredient. It changes the loose mixture into a rock-like old material. When you mix water with cement, it makes a paste. The paste goes around the particles and fills in the empty spaces. Typically, 150 to 200kg/m3 of water are used. The old rule of thumb for water quality is “if you can drink it, you can use it in concrete (gray, 2017).

2.5.2.2. Cement

Cement is a hydraulic bonding agent used in building construction and civil engineering. It is a fine powder obtained by grinding the clinker of a clay and limestone mixture calcined at high temperatures. When water is added to cement it becomes slurry that gradually hardens to a stone-like consistency. There are two types of cement: natural and artificial.

The natural cements are obtained from natural materials having a cement-like structure and require only calcining and grinding to yield hydraulic cement powder. Artificial cements are available in large and increasing numbers. Each type has a differentcomposition and mechanical structure and has specific merits and uses. Artificial cementsmay be classified as Portland cement (named after the town of Portland in the United Kingdom) and aluminous cement (Neville, 2022).

2.5.2.3. Aggregate

The fine and coarse aggregates generally occupy 60% to 75% of the concrete volume (70% to 85% by mass) and strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy. Fine aggregates generally consist of natural sand or crushed stone with most particles smaller than 5 mm (0.2 in.). Coarse aggregates consist of one or a combination of gravels or crushed stone with particles predominantly larger than 5 mm (0.2 in.) And generally, between 9.5 mm and 37.5 mm (3⁄8 in. And 11⁄2 in.). Some natural aggregate deposits, called pit-run gravel, consist of gravel and sand that can be readily used in concrete after minimal processing. Natural Gravel and sand are usually dug or dredged from a pit, river, lake, or seabed (alexander &mindess, 2020).

Crushed stone is produced by crushing quarry rock, boulders, cobbles, or large-size gravel. Crushed air-cooled blast-furnace slag is also used as fine or coarse aggregate. The aggregates are usually washed and graded at the pit or plant. Some variation in the type, quality, cleanliness, grading, moisture content, and other properties is expected. Close to half of the coarse aggregates used in Portland cement concrete in north America are gravels; most of the remainder are crushed stones (surahyo, 2019).

Naturally occurring concrete aggregates are a mixture of rocks and minerals. A mineralis a naturally occurring solid substance with an orderly internal structure and a chemical composition that ranges within narrow limits. Rocks, which are classified as igneous, sedimentary, or metamorphic, depending on origin, are generally composed of several minerals. For example, granite contains quartz, feldspar, mica, and a few other minerals; most lime stones consist of calcite, dolomite, and minor amounts of quartz, feldspar, and clay. Weathering and erosion of rocks produce particles of stone, gravel, sand, silt, and clay (strange,2018).

2.5.2.4. Admixtures

Admixtures are those ingredients in concrete other than Portland cement, water, and aggregates that are added to the mixture immediately before or during mixing. Admixtures can be classified by function as follows: air-entraining admixtures, water- reducing admixtures, plasticizers, accelerating admixtures, retarding admixtures, hydration-control admixtures, corrosion inhibitors, shrinkage reducers, alkali-silica reactivity inhibitors and coloring admixtures (Dodson, 2019).

2.6. Function requirement of construction structures

2.6.1. Walls

The main purpose of walls in building construction is not only to protect buildings from damage but also to divide them for different rooms or spaces. There are various Functional requirements of walls that should satisfy to perform its functions adequately. The commonly accepted requirements of a wall are: strength and stability, resistance to weather and ground moisture, durability and freedom from maintenance, fire safety and resistance to the passage of sound (seele,2021).

2.6.2. Floor

A floor is the bottom surface of a room or vehicle. Flooring is the general term for a permanent covering of a floor, or for the work of installing such a floor covering. A lot of variety exists in flooring and there are different types of floors due to the fact that it is the first thing that catches your eyes when you walk into a house, as it spans across the length and breadth of the house. It is also the surface that goes through the most wear and tear, and that's why choosing the right material is of utmost importance (seeley,2023).

2.6.3. Doors and windows

The general requirement for doors are the following: they are provided to give access to the inside of a room of a building, they serve as a connecting link between the various internal portions of a building, they provide lighting and ventilation of rooms, they control the physical atmosphere within a space by enclosing it, excluding air drafts, sothat interiors may be more effectively heated or cooled, they act as a barrier to noise, theyare used to screen areas of a building for aesthetic purpose, keeping formal and utility areas separate, the general requirements for windows, like the protection against the weather, day lighting, supply of fresh air and the connection to the outside, the meet thermal and acoustical (paul&taylor,2018).

2.7. Design of structural element

2.7.1. Slab

A concrete slab is a common structural element of modern buildings, consisting of a flat, horizontal surface made of cast concrete. Steel-reinforced slabs, typically between 100 and 500mm thick, are most often used to construct floors and ceilings, while thinner mud slabs may be used for exterior paving. The slab subjected to its own weight, the floor Covering and the live load and it supports on the beam. It was modeled by area. In many domestic and industrial buildings, a thick concrete slab supported foundations or directly on the subsoil, is used to construct the ground floor. These slabs are generally classifiedas ground-bearing or suspended. A slab is ground-bearing if it rests directly on the foundation, otherwise the slab is suspended (zareef,2020).

2.7.2. Beam

A beam is a structural element that primarily resists loads applied laterally to the beam's axis. 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 the 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. The beams subject to their own weight and the load from slab. The beam supports on columns and it was modeled by line. This line has start and end points(group *et al*, 2021).

2.7.3. Column

A column is a compression member, which is used primary to support axial compressive loads and with a height of at least three it is least lateral dimension. Depending upon the architectural requirements and loads to be supported, R.C columns may be cast in various shapes i.e. square, rectangle, and hexagonal, octagonal, circular. Columns of l shaped or t shaped are also sometimes used in multistoried buildings.The longitudinal bars in columns help to bear the load in the combination with the concrete. The longitudinal bars are held in position by transverse reinforcement, orlateral. The binders prevent displacement of longitudinal bars during concreting operationand also check the tendency of their buckling towards under loads. (hawileh,2020).

2.7.4. Foundations

In engineering, a foundation is the element of a structure which connects it to the ground, and transfers loads from the structure to the ground. Foundations are generally considered either shallow or deep. Foundation engineering is the application of soil mechanics and rock mechanics (geotechnical engineering) in the design of foundation elements ofstructure (Anderson et al, 2021).

2.7.5. Stairs

Building stairs are facilitated for people to whom they can access to the upper floor, stairsshould be designed so that they are convenient for most the people use because of the young or old people find it difficult to go up and down stair safety you should put sturdy handrails within reach the handrails should be support by balustrades on the open side of the staircase to prevent accident (peck, 2018).

2.7.6. Ramp

An inclined plane, also known as a ramp, is a flat supporting surface tilted at an angle, with one end higher than the other, used as an aid for raising or lowering a load. The inclined plane is one of the six classical simple machines defined by renaissance scientists. Inclined planes are widely used to move heavy loads over vertical obstacles; examples vary from a ramp used to load goods into a truck, to a person walking up a pedestrian ramp, to an automobile or railroad train climbing a grade. (giglio,2020).

2.8. Estimating

Estimating is the technique of calculating or computing the various quantities and expected expenditure to be incurred on a particular work or project. It is an approximate calculation of quantity or degree or work or project. It is an approximate calculation of quantity or degree or worth;" an estimate of what it would cost; a rough idea how long it would take." A cost estimate is a compilation of many elements, an approximation of the probable quantity and unit cost of each of the elements. It is not a single number. It has uncertainty and risk associated with its elements and it is used as a basis for makingfinancial decisions (pratt,2023).

2.8.1. Method of estimation

The method or procedures of estimating are preparing detailed estimate, calculating the rate of each unit work and preparing abstract of estimate.

2.8.2. Requirement for estimation

The information required by the estimator should include the following: the latest description of the intended project include in gall available drawings, specifications, job descriptions and the site location; the intended/required start and completion dates and latest programs; latest ideas on method of construction; sources of project funding with dates of availability; latest ideas on contract strategy and availability of resources together with any prescribed restrictions of choice; any papers or reports describing performance and problems encountered on similar projects in similar locations; anycost/productivity data relating to the project or current construction projects in the' host country (build, 2018).

CHAPTER 3: MATERIALS AND METHOD

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. Location of the site

This Fig.1 shows the site location which located in KIREHE district, Mahama 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.

3.2.1. Map of the study

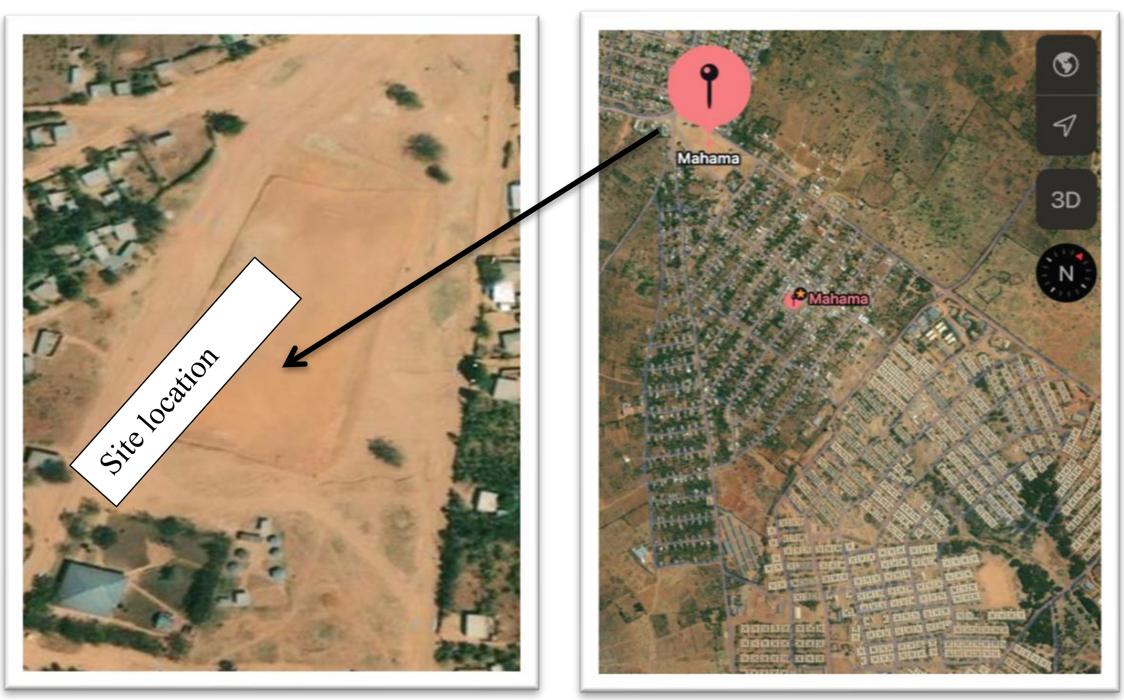

Figure 3. 1.Study area

3.3. The data collection method

3.3.1. Primary data collection

The methods used in this dissertation research were based primary data especially interview which was given to the people of Mahama a 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 theproposed 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.

Table 3. 1.Showing design information

Information	Meaning
Euro code2: The structural use of concrete 1992	Building regulations and designCodes
Floor: - Imposed load (Maximum) = 4 KN/ m^2Stairs: - Imposed =4 KN / m^2 Finishes = 1.5 KN / m2 live loads: 4.79 KN / m^2	General load conditions
Safe bearing pressure :240 KN / m^2	Sub soil conditions
Concrete grade: fcu = 24KN / m^2 forReinforcement: fy = 450 N/ mm^2 for stirrup = 250 N/mm^2 Self- weight: -Reinforced concrete = 25 KN /m^3Masonry = 20 KN / m^3	Data corresponding to givenmaterials
1.4 for dead load 1.6 for live load	Partial safety factors

Formulas used in the design project

The thickness of the slab lies between $\frac{lx}{12}$ and $\frac{lx}{40}$ where lx is the shorter side of the panel,

Using the biggest panel among others

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

3.3.2. Design of slab

3.3.2.1. Dead load

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

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

Total dead load= self-weight – finishes

3.3.2.2. Live load

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

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

3.3.3. Bending moment on the slab

Mx=βsx*n*lx^2

My=βsy*n*lx^2

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

βsx and βsy are coefficient related to the design of slabs

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

3.3.4. Required area of steel reinforcement on slab

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

Beam design

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

Computation of web of flange of the beam (bw)

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

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

Computation for T beam of the flange (bf)

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

- **Loads on the beam**

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

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

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

3.3.3.1. Load on column

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

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

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

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

+width of influence area) × unit weight

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

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

3.3.3.1. Live load

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

3.3.3.2. Load applied on the floor of the column

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

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

3.3.3.2. Steel reinforcements for the column

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

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

Foundation design

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

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

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

Estimation foundation weight soil =10 % of total characteristic load

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

3.3.3.2.1. The required area of foundation

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

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

WhereA_f: area of foundation

Pb is the bearing capacity of the soil

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

3.3.3.2.2. Checking of shear force

The shear force Q ≤0.54Rbt*Ab

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

Ab=af*h_o

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

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

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

3.3.3.2.3. Moment calculation

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

Where p is the design pressure

af is side of foundation

ac is side of the column

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

3.3.3.2.4. Stairs design

The condition of slope relationship$550<2R+G<700$, where T is tread and R is riser.

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

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

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

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

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

Live load is taken as building design live load plus 1.5KN/m^2 with a maximum value of4KN/$m^{2.}$

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

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

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

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

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

3.4. Load on the ramp

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

Live load = safety factor × live load of material

3.5. Calculation of steel reinforcement in the ramp

Am=$\frac{M}{\eta . fcu.b.d^2}$Where αm: coefficients related to the design of members subjected to bending moment Rb: design concrete compression strength, b is the width of the compressive area and d: effective height (m) can be positive or negative if m is positive = is the moment at thebottom if m is negative the moment is at top.

3.6. Ground beam design

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

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

Table.3. 2.Project information and related data for the proper design

Project:	An implementation of Modern Market building
Location:	Mahama sector, Kirehe District, Eastern province –Rwanda
Drawn by:	Ndagijimana Pilote
Structural Design: Supervised by:	Ndagijimana Pilote Eng. Bonaventure Nkiranuye
THE USED codes:	BS8110 Part 1 & 6399
Design Stresses data:	Concrete: f_{cu}= 25 N.mm^2; Steel: f_y=460N.mm^2(High yield steel), f_{yk}= 250 N.mm^2(Lower yield steel) R_{bt}=0.09N/mm^2 R_{sw}= 328 N/mm^2 fy= 460N/mm^2 for main barsfy=250N/ mm^2 for links fcu=30N/ mm^2 for concrete fcu=35KN/ mm^2 for concrete in foundation
Fire resistance:	One hour for all elements
Exposure condition:	Mild for all elementsCover: 20 mm Slab, Stairs & Beams: 25mmColumns: 30mm Thickness of plaster =30mm
Soil Condition:	Firm gravely lateritic clay. Allowable bearing capacity: 300 kN/m^2
General loading conditions:	Live load: 4kN/m^2 Unity weight of concrete = 24 KN/m3 Unity weight of masonry = 18KN/m3Unity weight of plaster =20 KN/m3 Modulus of elasticity of concrete E_c=2*10^{4}Mpa

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This building consists of a five story Modern market building which located in Eastern province Kirehe district Mahama sector, it has 27rooms each floor and ground floor aredimensioned of 3438cm*4136 and first floor up to five floors are the same dimension of 3230cm*3930cm. It has a five story where from the ground floor to the five floors is for market purposes.

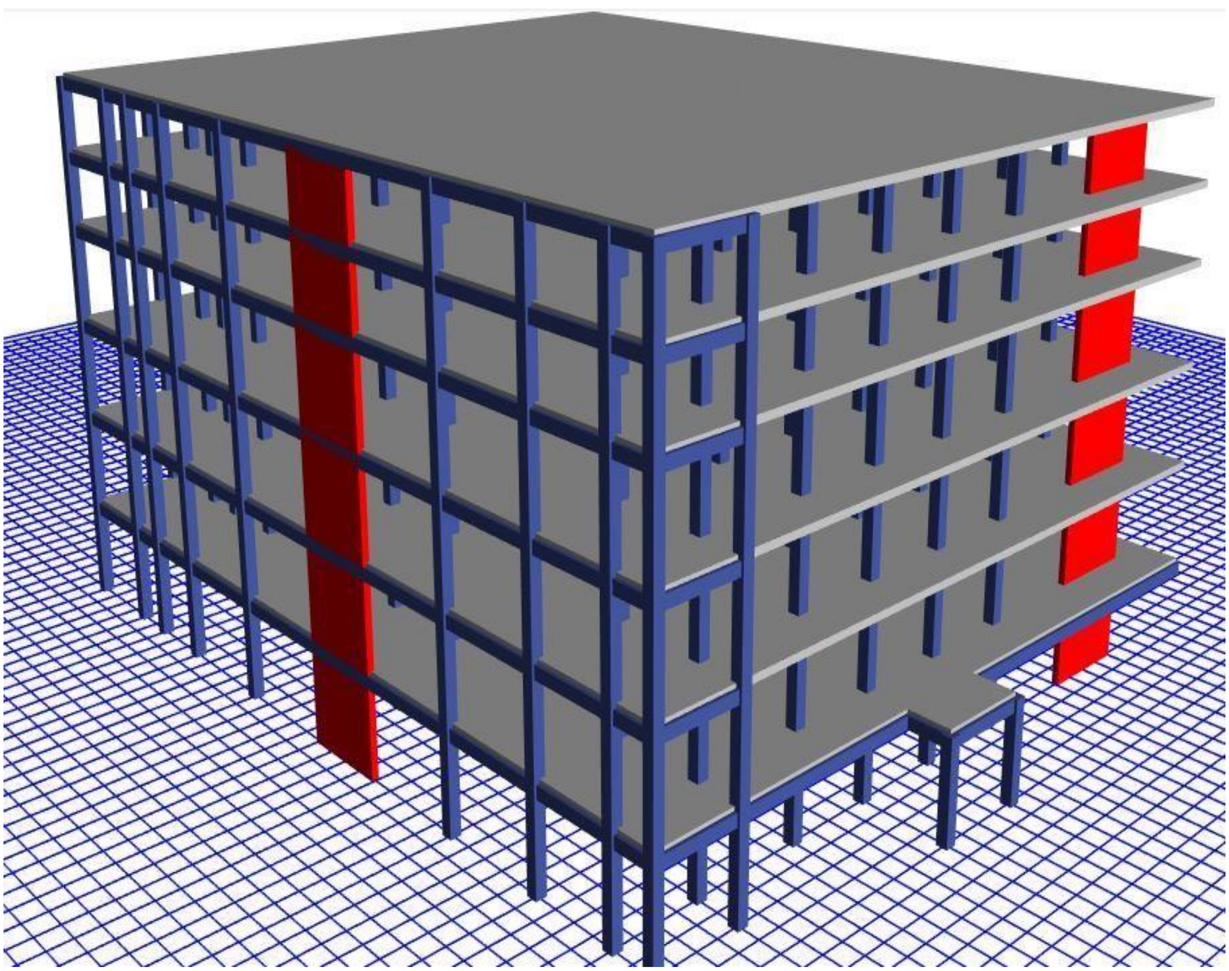

Figure 4. 1.indicated Frame structure

4.1.1 Ground floor

Figure 4. 2.Indicated Ground floor

A floor which composed with shops, supermarket and toilets whose dimension of ground floor are 3438cm*4136cm and first floor up to five floors are the same dimensioned of 3,230cm*3,930cm. inside will construct for partition walls have ability to occupies access of people used for the affordable place, it has also up rise stairs of two sides and lamp stair for people with disabilities it is favorable to access in the market easily.

4.1.2. First floor up to five floors

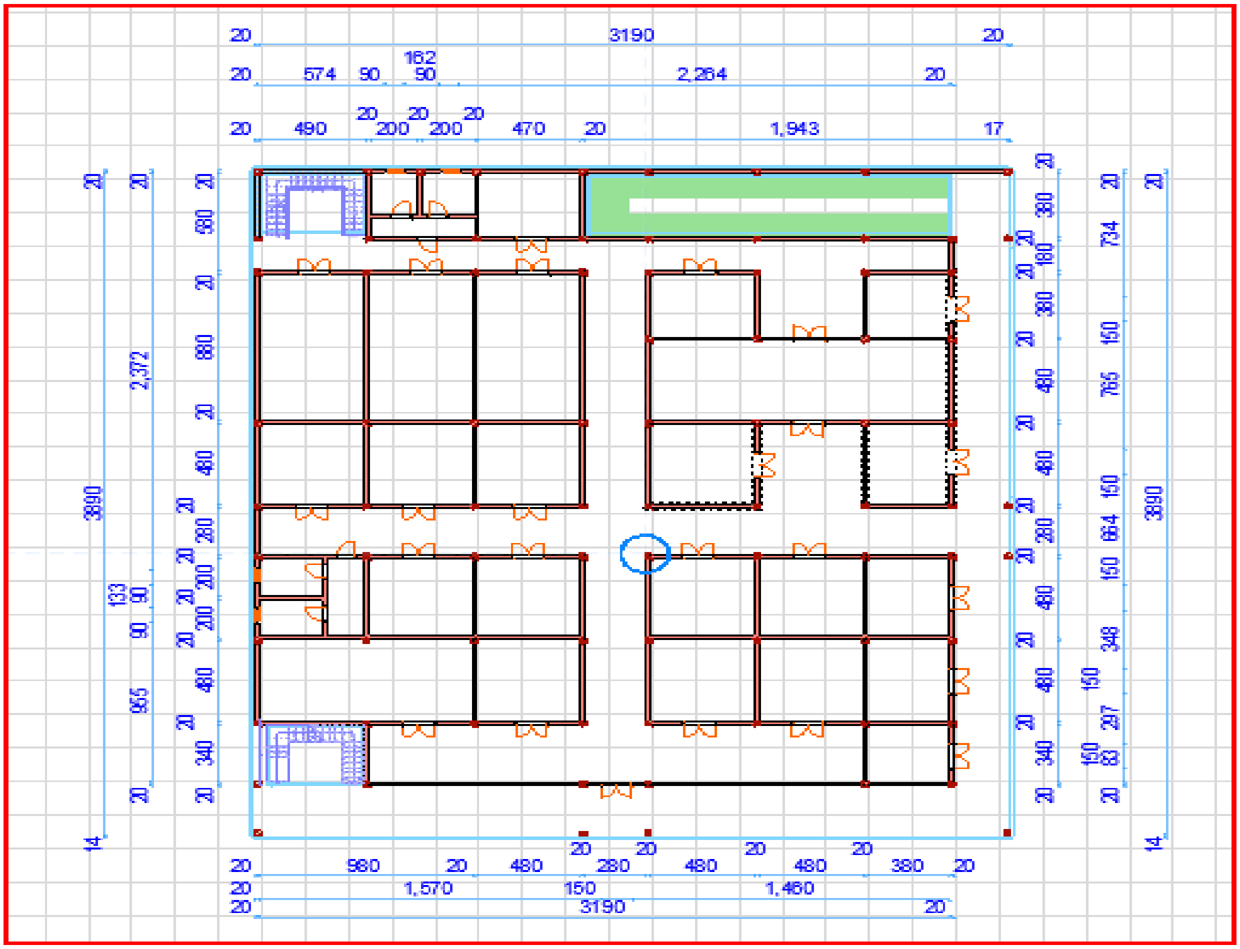

Figure 4. 3.indicated first floor up to five floors

First floor is a floor which has the same dimension of other floor above to five floors but it contains27rooms consist of supermarket shops, toilet and control room big room has 960*480cm, small room has380*480cm, hall has 200cm and toilet has180*200cm without veranda.

4.2. Structural design elements

4.2.1 Slab design

Slab is horizontal plate elements carrying lateral loads. They may be simply supported or continuous over one or more supports and are classified according to the method of support as follows: Spanning one way between beams or walls, spanning two ways between the support beams or walls, and flat slabs carried on columns and edge beams or walls.

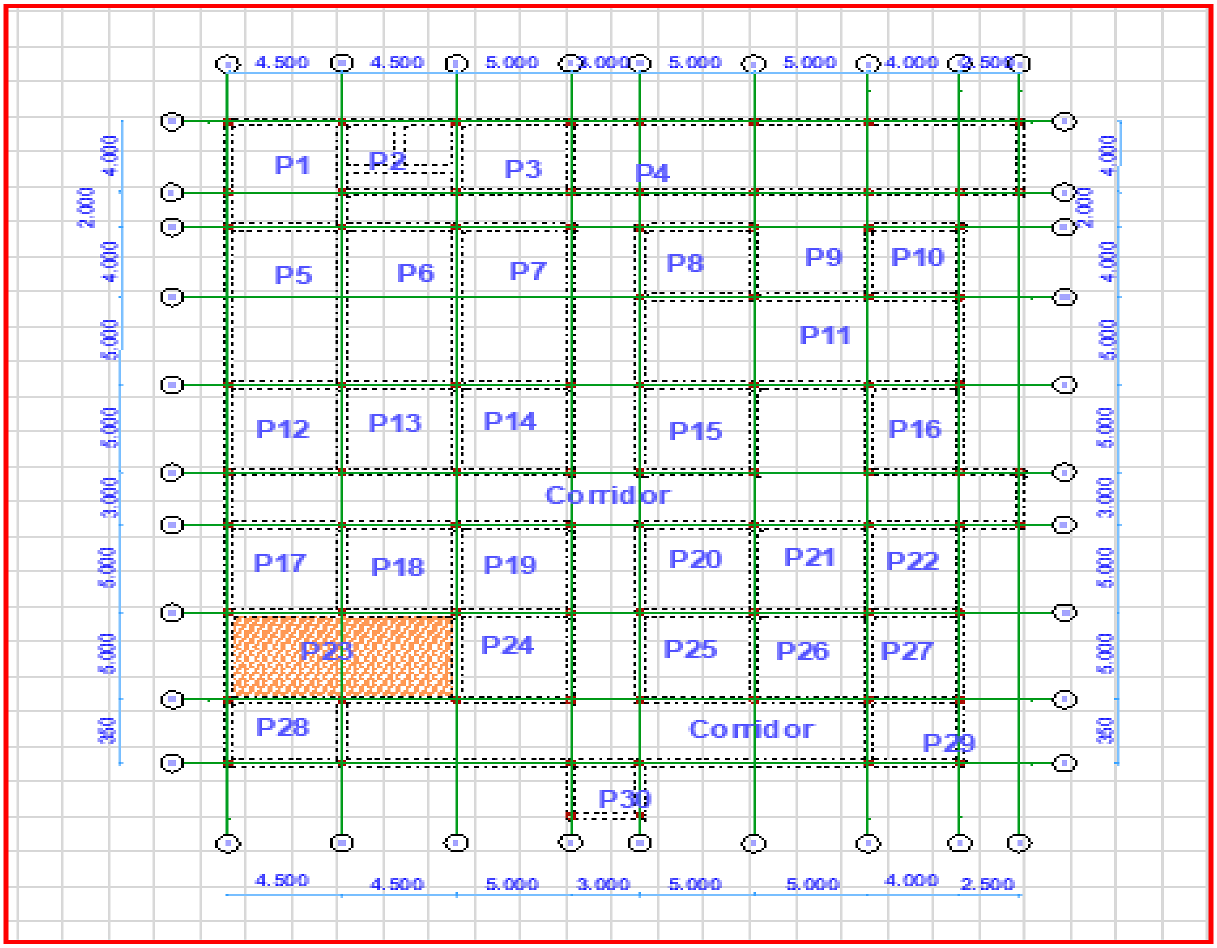

Figure 4. 4.indicated Designed slab panels with grids

4.2.1.1 Panel Slab thickness

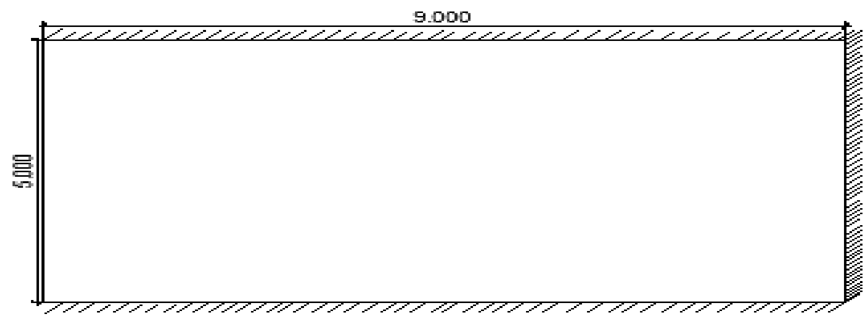

Figure 4. 5.Critical panel of slab

Calculation of the depth of slab

The thickness of the slab lies between Lx/25 and Lx/40; where Lx is the short side of thepanel. Considering the biggest panel among others; taken (D, E, I, III) of 9mx5m.

Hf=$\frac{500}{25}$=20cm in comparison with $\frac{500}{40}$=12.5 cm

As the thickness of the slab (h_f) lies between 20cm and 12.5cm,let take h_f =18cm.

The effective height (d) = thickness of the slab – the clear cover = 15-2.5= 15.5cm

The effective height of the slab (d) =15.5cCalculation of steel reinforcement in the slab

Calculation of total load on the slab

a) Dead load
b) Self-load= 1.4*1*1*0.18*24KN/m= 6.048KN/m^2
c) Finishes= 1.4*1*1*1.8KN/m= 2.52KN/m^2
d) Total dead load= 6.48KN/m^2 + 2.52KN/m^2 = 8.568KN/m^2
e) Live load
f) The weight of live load for house used as Modern market is equal to 4.79KN/m^2
g) Live load= 1.6*1*1*4.79KN/m= 7.664KN/m^2

1. Total load on the slab = 8.568KN/m^2 + 7.664KN/m^2 = 16.232KN/m^2

Ly= 9m, Lx= 5m

$\frac{ly}{lx} = \frac{9}{5} = 1.7 < 2(two$ way slab)

C. Calculation of bending moment

Mx=βsx*n*lx^2

My=βsy*n*lx^2

$\mathbf{M}_x^-$ = 0. 101 * 16.232 * 5^2 =40. 985KNm

$\mathbf{M}_x^+$ = 0.049 * 16.232 * 5^2 = 19.884KNm

$\mathbf{M}_y^-$ = 0.047 * 16.232 * 5^2 = 19.072KNm

$\mathbf{M}_y^+$ = 0.019* 16.232 *5^2 = 7.710KNm

D. Steel bars calculation

Rb = 1.4KN/cm^2

Rs = 40KN/cm^2

M^-max= 40.985KNm

M^+ max=19.884KNm

E Required steel reinforcement at the top

K=$\frac{M}{fcubd^2}$=$\frac{49.98knm*10^6}{30*1000*155^2}$=0.06

Z=d[0.5+$\sqrt{0.25 - \frac{k}{0.9}}$]not >0.95d

$Z=155[0.5+\sqrt{0.25-\frac{0.06}{0.9}}]$=143.86mm<0.95*155=147.25mm

Let take z=143.86mm

Required steel reinforcement at the bottom

As $=\frac{M}{0.95fyz}$ $=\frac{49.98KNm*10^6}{0.95*460*143.86}$=795$mm^2$

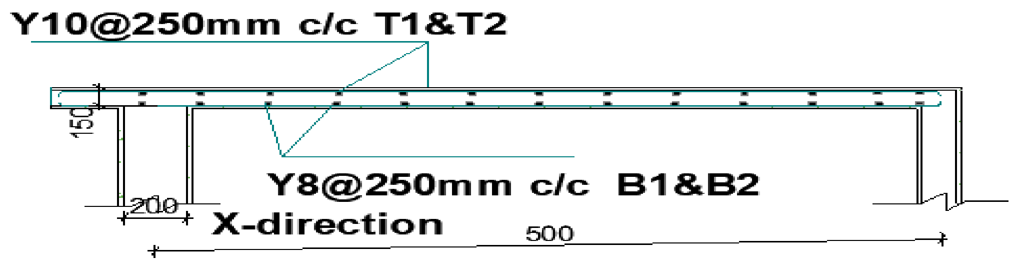

Figure 4. 6.indicated Cross-Section of slab with frame

Discussion

This **Fig 4.6** shows how the steel reinforcements are arranged in the slab and this figure show the section of steel reinforcement sizes and the spacing between bars to be used in the slab. The steel found for slab on top and bottom which has the diameter greater or equal to 8mm the minimum diameter for slab has to be equal or greater than 8mm.

All slab panels have the thickness which equal to 180mm which is in the range between 100mm to 500m means the slab thickness are good. to say that The reinforced concrete design slab for buildings has to be in the range 100 to 500mm. the calculations of steel bars on top and bottom are required for slab in order to resist for the bending moment (Johnson, 2018).

4.2.2 Beam design

4.2.2.1.Beam 1(B-B) design

Method of calculation to determine shear force and bending moment. Beam in generally used in a building frame to carry the loads from the slab through on beam those loads are carried directly to the column. The beams are analyzed and dimensioned to resist the actions and reaction which are applied on it.

With: Lmax –Effective span.

Design loads: 1.4 G_K+1.6 Q_K.

Computation for the depth of the beam (h)

$\frac{lmax}{15} \leq h \leq \frac{lmax}{8}$

Where Lmax is the largest span of the beam between two support

from the structural plan.

$\frac{943}{15} \leq h \leq \frac{943}{8}$=>62.86≤h≤117.87, let take h=70cm

4.2.3.Computation for the breath of the beam (bw)

$0.5 \leq bw/h \leq 1$, where h= 60cm

$0.5 * 60 \leq bw \leq 1 * 60$ =>$30 \leq bw \leq 60$,

Let Take bw = 30cm

Determination of width of flange (bf)

- For the section of T beam

Bf= $\begin{cases} 1/3 \; of \; the \; beam \; span = 1/3\,(943) = 314.33 cm \\ 1/2 \; of \; the \; distance \; between \; beams = 1/2(400) = 200\text{cm} \\ 12.hf + bw\;(for\ \text{T}\ section) = (12 * 18) + 30 = 246 cm \end{cases}$

For the section of L-section beam is equal to the smallest value of the following:

Bf= $\begin{cases} 1/3 \; of \; the \; beam \; span = 1/3\,(943) = 314.33 cm \\ 1/2 \; of \; the \; distance \; between \; beams = 1/2(400) = 200\text{cm} \\ 6.hf + bw\;(for\ \text{T}\ section) = (6 * 18) + 30 = 123 cm \end{cases}$

For this case T beam, bf of the beam will be 314.33cmFor the case L beam, bf of the beam will be 138cm

Table 4. 1.shows inputs of design parameter of the beam

Fcu (MPa)	25
Fy (MPa)	450
Fyv (MPa)	250
% Redistribution	0
Downward/Optimized redistr.	D
Cover to centre top steel(mm)	25
Cover to centre bot.steel(mm)	25
Dead Load Factor	1.4
Live Load Factor	1.6
Density of concrete (kN/m3)	24
% Live load permanent	25
Ø (Creep coefficient)	2
Ecs (Free shrinkage strain)	300E-6

Load on beam Permanent load

Self-weight of the beam=1.4*0.3*0.6*1*24=6.048KN⁄m

Cement plaster on the beam=1.4*0.03*0.84*20=0.705KN⁄m

Load from slab=8.568*2.1=17.99KN⁄m

4.2.3.1. Dead load

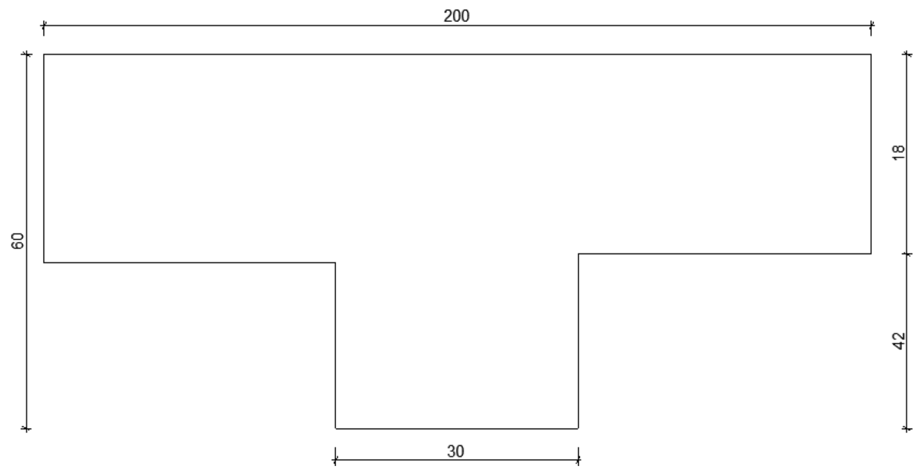

Figure 4.7.indicated designed beam section

Masonry wall=1.4*0.2*3.4*1*19=18.08KN⁄m

Finishes wall=1.4*0.03*3.82*20*2=64.176KN⁄m

Live load Vn for public building like a Market house.

Vn=4.79kN/ m^2

Live on the slab

Live load on the slab:7.664*2.1=16.07KN⁄m

Permanent uniformly distributed load (G1)

=64.176+18.08+17.99+0.705+6.048=.1069.99KN ⁄m

Live loads from slab (Q2) = 16.07KN⁄m

Bending moment and shear force due to rectangular loads

Mmax= WL^2

Vmax= (aG+bQ) L

Then follow the table of coefficient α;and a; b to find out the values which related theratio of C ⁄L, where C=Lx⁄2

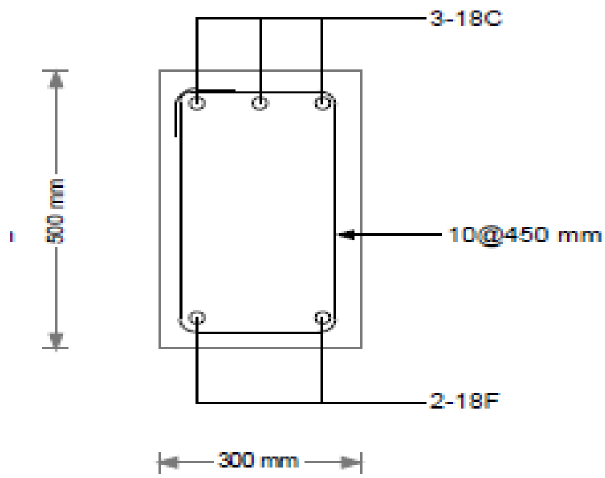

Figure 4. 8.indicated Cross-Section of Beam

Checking deflection

The deflection fu= Lmax ⁄ 500

fu= 943 ⁄500=18.86mm

Safety deflection should be greater than maximum long-term deflection for this longitudinal beam the maximum long-term deflection is 4.624mm which is lesser than the ultimate deflection fu=18.86mm and shear wall can be support beam for deflection.

Column design

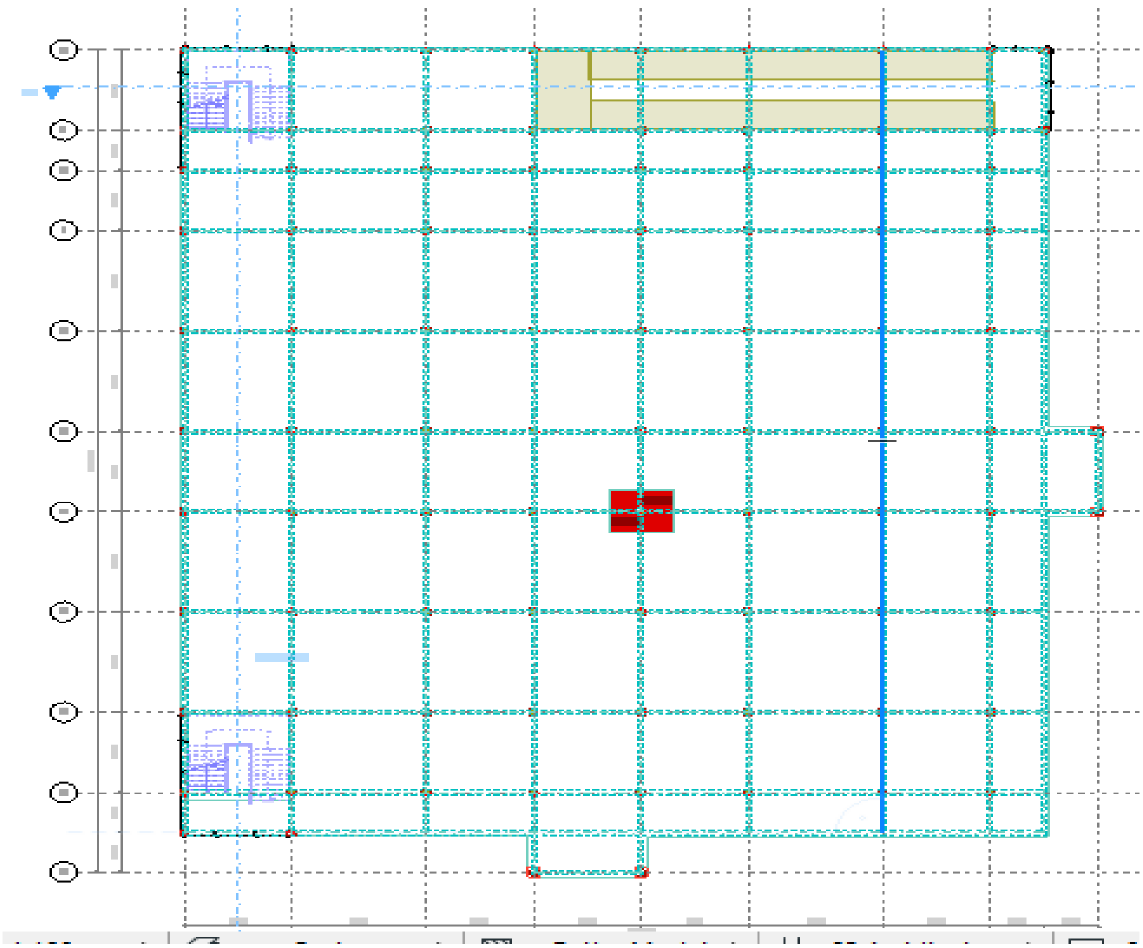

Figure 4.9.showing the size and the column location

Let use cross-section of: a =40cm, b=40cm

The height of the wall masonry =4m-0.60m=3.4m

The height of the area of the plaster=4m-0.15m=3.85m

Information about beam and slab which transmit their loads on the column

Area of influence on column= [(2.00+2.00)]*[(2.5+2.5)] m^2=20m^2

- Slab area that has influence =20m^2
- Length of beam on the column=4 + 5=9m

Calculation of dead load

Self-load of column= (1.4*0.4*0.4*1*24) KN=5.376 KN /mLoad from the slab = (16.232*5*4) KN =150.36 KN

Load from the plaster=1.4*0.03*3.85*9*2*20* KN =58.212KN Load of masonry wall =1.4*1*0.20*9*3*18* KN =136.08 KN Load from the beam =1.4*1*0.30*0.6*9*24* KN =54.43 KN **Calculation of live load**

Q_k=1.6*[58.212*4.79$^{] =}$ 278.83KN

Total computation on the floors

Loads = (load from slab + masonry wall + plaster wall + load from the beam +live load)

* Number of stories + (self-load of column* height of the stories) + (load from the slab +live load + load from the beam).

Loads from the roof=54.43x1=54.43KN

Ground floor part of the column

N_1=[(150.36+136.08+58.212+54.43+278.83)*4+(5.376*5)+150.36+278.83+54.43] KN

=3222.148KN

First floor loads

N_2== (150.36+136.08+58.212+278.83) x3+(5.376*4) +(150.36+278.83) +54.43=2375.57KN

Second floor loads

N_3= (150.36+136.08+58.212+278.83) x2+(5.376*3) +(150.36+278.83+54.43) =1746.712KN

Third floor loads

N_4= (150.36+136.08+58.212+278.83) *1+(5.376*2) +150.36+278.83+54.43=1117.854KN

Fourth floor loads

N_5= (150.36+136.08+58.212+278.83) *0+(5.376*1)+ 150.36+278.83+54.43 =488.996KN

Fifth floor loads

N_6= 150.36+278.83+54.43 = 483.62KN

Slenderness ration of column***:***

For internal column we multiplied by 0.7H/a

For external column we multiplied by 0.9*H∕a

This a is the small side of cross-section of column height=340; a=40

Effective height=340*0.7=238cm Column slenderness: ƛ=hf/a=238/40=5.95

So, our column is considered to be short column due that5.95<14.3 thus our column is short

So, φ will be 0.92 λ=6

Table 4. 2.indicated slenderness ratio and steel design in the column

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

As=$\frac{\frac{N}{\emptyset}-Ab*Rb}{Rs}=\frac{\frac{3222.148}{0.92}-1.4*40*40}{40}=26.197cm^2$

Let take 4 ∅12 with As=52.75cm^2

Diameter for stirrups Ø=1/4$ØC = 1/4 * 12mm = 3mm$

Let use ø8@ 574mm

Space between stirrups is given by following equation:

$$S = \begin{cases} 12ØC \\ a \\ 300mm \end{cases}$$

$$S = \begin{cases} 12*12=144mm \\ 300\text{ mm, let use } S=100mm \\ 300mm \end{cases}$$

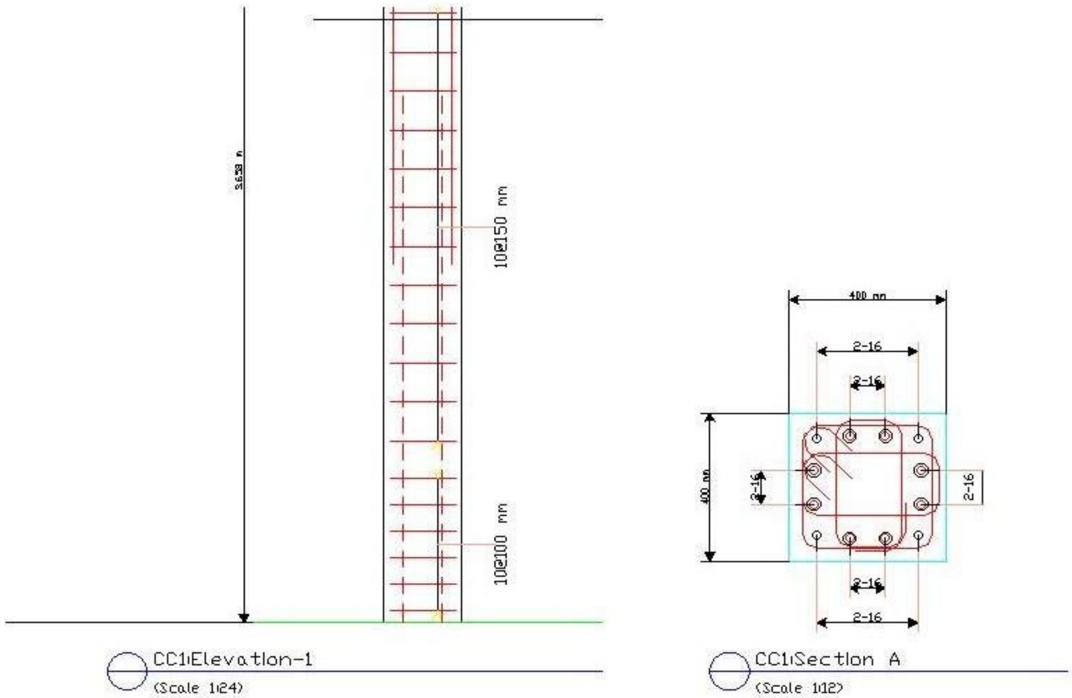

Figure 4. 10.indicated Longitudinal Section of column

During the column design the followings result were obtained

Table 4. 3: Column Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story1	C5	128	RC Column 60	DCon4	3500	4000	0.582

Table 4. 4.indicated Axial Force and Biaxial Moment Design For N , M2 , M3

Design N kN	Design M2 kN-m	Design M3 kN-m	Minimum M2 kN-m	Minimum M3 kN-m	Rebar Area mm^2	Rebar % %
2479.0111	-27.8074	65.8672	49.5802	49.5802	1000	0.4

Table 4. 5.Shear Design for V2, V3

	Shear VkN	Shear V_c / ɣM kN	Shear V_s / ɣM Kn	Rebar A_{sv} /s mm^2/m
Major, V_2	30.0738	485.9845	90.5004	555.98
Minor, V_3	6.9822	485.9845	90.5004	555.98

4.2.4 Pad foundation design

A building typically consists of two main parts: the superstructure above the ground and the foundation below ground. The foundation's primary role is to transfer and distribute the loads from the structure's columns and walls into the ground. This ensures that the ground can safely support the weight without exceeding its safe bearing capacity. If the bearing capacity is exceeded, it can result in excessive settlement, potentially causing damage to the building and its service facilities. If the load from the superstructure surpasses the soil's bearing capacity, modifications to the footing, such as increasing its dimensions, may be necessary to ensure stability.

i.e., assumed that:

Depth of foundation=1m; soil bearing capacity is 300KN/m2,Fcu=25KN/m, fy=460KN/m2 as H=60

Table 4. 6.unfactored load

		Unfactored Loads						
Load Case	Col no.	LF ULS	LF ULS	P (kN)	Hx (kN)	Hy (kN)	Mx (kNm)	My (kNm)
1	1	0.9	1.4	1686.4				

Calculation of bending moment

Mmax=$\frac{p*af}{2}(\frac{bf-bc}{2})^2$=$\frac{0.0220*400}{2}(\frac{400-40}{2})^2 = 2851.20\ Kn$

Required area of steel reinforcement in foundation

As=$\frac{M}{0.95*h*Rs} = \frac{2851.20}{0.9*55*40} 14.4cm^2$

Steel reinforcement provided 6ϕ25mm

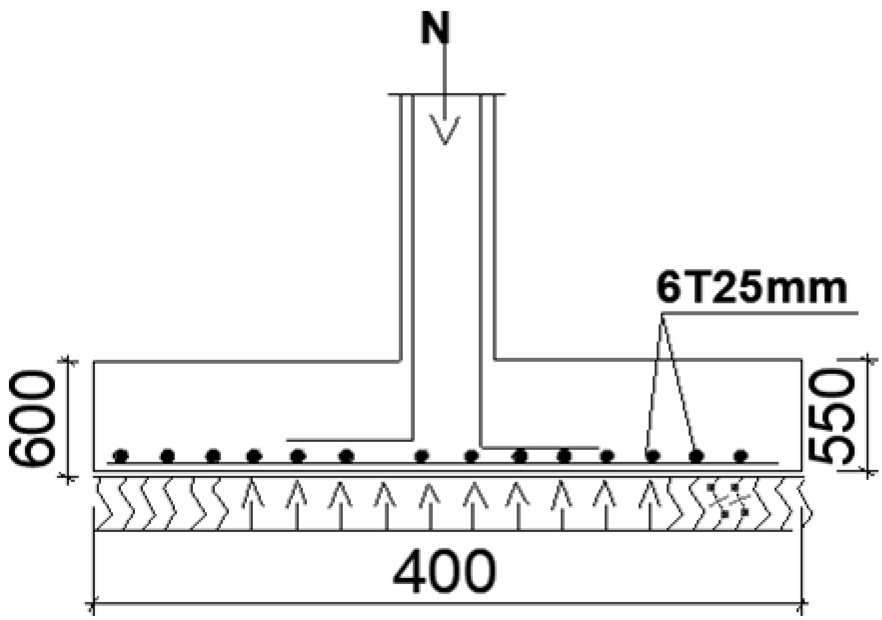

Figure 4. 7.indicated Steel reinforcement diagram

Design of pad foundation for the column

Column design load = 4002.212KN

Total design live load of the slab = 278.83KNx6 =1672.98KN

Total design permanent load=4002.21−1672.423KN=2329.232KN

Total characteristic live load=1672.98KN/1.6==278.83KN

Total characteristic permanent load=$\frac{2329.232KN}{1.4} = 1663.73KN$

Total characteristic load =278.83KN+1663.73KN=1942.56KN

Estimated foundation weight = 10% *1942.56KN = 194.256KN

Total load on the soil= 1942.56KN + 1942.56KN = 3885.12Vkn

T he soil bearing capacity=300KN ⁄m^2

The required area of foundation

Af=$\frac{service\ load}{bearing\ capacity\ of\ soil}\ or\ \frac{GK+QK+W}{Pb}$

Af =$\frac{3885.12KN}{300KN/m} = 12.95m^2$

The size of footing is the square of footing $\sqrt{Af}$=$\sqrt{12.95}$=3.59m

Af =3.59m*3.59

Size of column =0.3m*0.3m

Provide a base B=4m, L= 4m

Concrete cover=50mm

The foundation a cross section 400cm*400cm with an assumed thickness of 60cm.

Design pressure P=$\frac{Design\ load}{Area\ of\ footing}$

P=$\frac{3885.12Kn}{400*400}$=0.024KN/$cm^2$=242KN/$m^2$

The design pressure P is less than Bearing capacity Pb

P<Pb, 242KN/m^2<300KN/m^2,thus the size of footing is adequate.

Hf =60cm

ho=Hf-concrete cover=60-5=55cm=550mm

Myy=P*($\frac{af-ac}{2}$) $* af *$ ($\frac{af-ac}{4}$)

Myy=242KN/m*($\frac{3.59-0.3}{2}$) $* 3.59 *$ ($\frac{3.59-0.3}{4}$)

Myy=242KN/m*1.645*3.59*0.8225

Myy=1175.47KNm

Thickness of footing =$\frac{size\ of\ footing + size\ of\ column}{4} = \frac{3590mm+300mm}{4} = 972.5mm$

Let assume h=1000mm

Effective depth of top layer d=h-cover-$\emptyset\ top\ bar - \frac{\emptyset top\ bar}{2}$

d=1000-50-16-16/2

d=934mm

k=0.156fcubd^2

k=$\frac{M}{fcubd^2}$ =$\frac{1175.47KNm*10^6}{30*4000*934^2}$=0.011

Z=d (0.5+$\sqrt{0.25-\frac{k}{0.9}}$) not greater than 0.95d

Z=934(0.5+$\sqrt{0.25-\frac{0.011}{0.9}}$)not greater than 0.95*934, Z=934*0.98>0.95*934

Let take Z=0.95*934=887.3mm $\approx 888mm$

As=$\frac{M}{0.95fyZ}$ =$\frac{1175.47*10^6}{0.95*460*888}$ $\quad As = 3029mm^2$

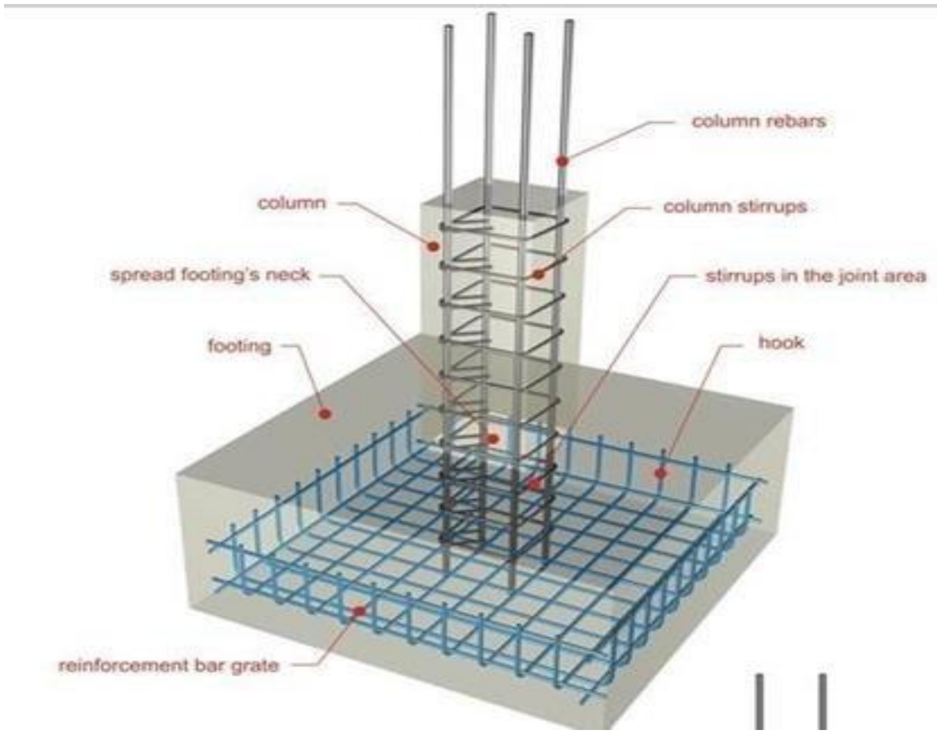

Figure 4.11.indicated Steel arrangement on foot

Discussion

The primary goal of foundation design is to ensure that structures perform reliably throughout their intended lifespan. To achieve this, the foundation must meet an acceptable level of safety, sustaining all expected loads and deformations that occur during normal use. Additionally, it must demonstrate sufficient durability and resistance to factors such as misuse and fire. In essence, a well-designed reinforced concrete foundation should provide the necessary strength and stability to support the structure, ensuring its safety under various conditions.

4.2.5. Design of reinforced concrete stairs case

size and loads calculation

The value of DL lies between ($\frac{1}{2}$ and $\frac{1}{30} * 9$)

Where DL is the effective depth of stair, H is the of the stair

Dl values between $\frac{400}{20} = 20cm$ and $\frac{400}{30} = 13.33cm$,taken Dl=15cm

Height of riser (h) = 18cm Length of going (g) = 30cm

$\alpha = arctan\frac{18}{30}$=$30^0$

We have to design one part of stair because all two parts are similar

Hl=$\frac{d}{cos\alpha} + \frac{h}{2}$=$\frac{15}{cos30} + \frac{18}{2}$=26.32

Ho=hl-concrete cover =26.32cm-2.5cm=23.82cm

Dead loads=1.4*0.2382*1*1*24=8.003KN/m^2

Loads from finishes =1.4*1.7=2.38KN/m^2

Live load=1.6*5=8KN/m^2

Total load=8.003+2.38+8=18.383KN/m^2

Total loads from slab=16.232KN/m^2

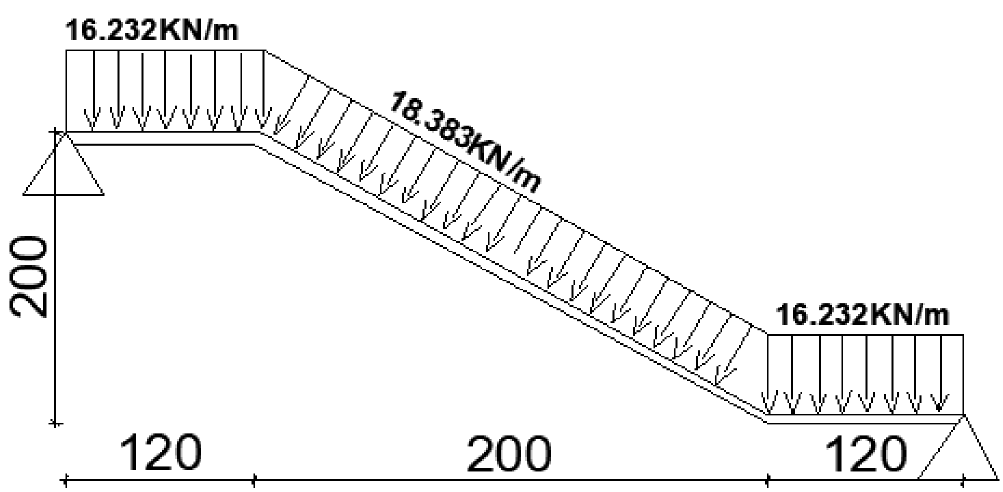

Figure 4.12.indicated Equivalent uniform distributed loads

Fig.4.12, this figure shows how the load are distributed to the stairs according to their span, The span of 1.2m loading 10.44KN/span 3.6m loading 13.15KN/m and span of 1.2m loading 10.44KN/m.

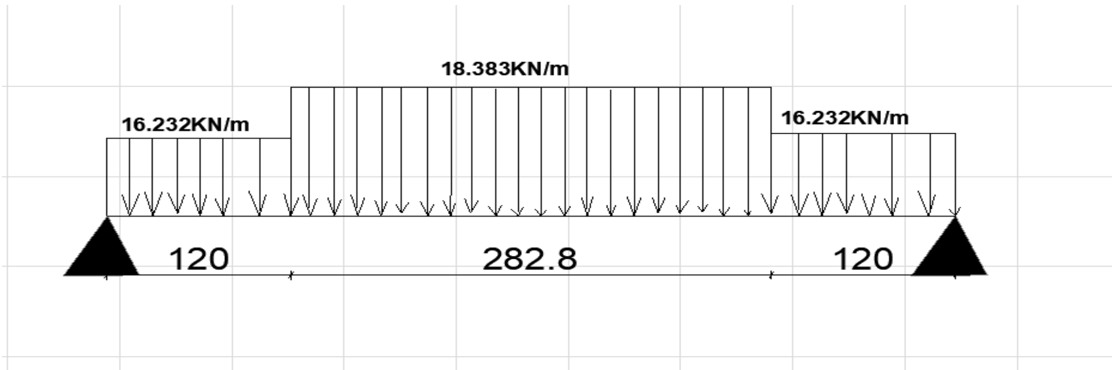

Figure 4.13.indicated Equivalent uniform distributed loads

Calculation of support reaction

$\sum Fv$ =0;

Ay + By = (16.232*1.20) + (18.383*2.828) + (16.232*1.20) = 72.56KN

$\sum MA$= 0;(-16.232*1.20*0.6) - (18.383*2.828*3) - (16.232*1.20*5.8) + (5.4By) =280.62 KN

5.4 By = 280.62 KN

by =$\frac{280.62KN}{5.4}$= 51.96KNm , Ay = 20.6KN

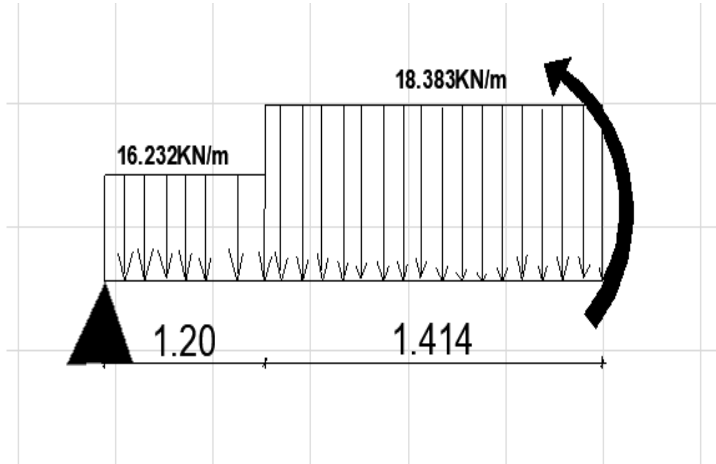

Figure 4.14: indicated Equivalent uniform distributed loads

This fig4.14: it shows uniform distribution lads on the stairs for getting maximum bending moment and reaction acting on stairs, this help to get all calculation needed for to get bending moment.

$\sum Mmax = 0$;

M_{max} = (43.5*3) -(16.232*1.2*2.4) - (16.232*1.414*0.5) =72.27KN/m

M_{max} = 72.27KNm

$$\alpha m = \frac{Mmax}{Rb*ho^2*b} = \frac{72.27*100}{1.4*23.8^2 1.414} = 0.090$$

αm = 0.090 which corresponds to ξ = 0.01; from the table of coefficients related to thedesign of members subjected to bending moment.

$\xi = 0.01$; $\xi < \xi_R = 0.950$ (case of singly reinforcements)

$\eta = 0.950$

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

$= \frac{72.27*100}{0.95*23.82*40} = 7.984 cm^2/m$

As=7.984cm^2/m

With this cross section, we use the minimum steel cross section: 6Φ12mm/m With $\mathbf{A_s}$ = 798.4mm^2/m

The landing width is equals to 15cm as for the slab.

The minimum area of steel reinforcement for hot rolled mild steel:

$As = \frac{0.24*b*h}{100} = \frac{0.24*141.4*15}{100} = 5.09 cm^2/m$

We provide 4Φ12mm/m with As =509.04 mm^2/m

4.2.6. Steel arrangement (Stair case)

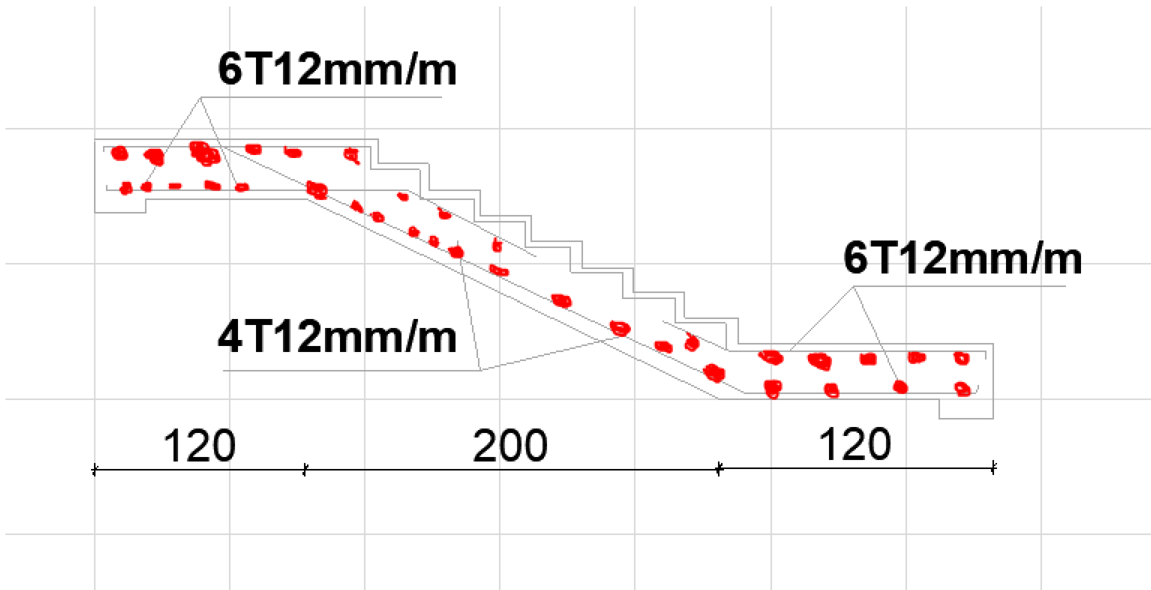

Figure 4.15. indicated Steel arrangement (stair case)

4.2.7. Discussion

The design of stairs has followed the euro code standards with manual calculations and formulas for calculating bending moment and shear force, in the results the steel reinforcements have been calculated and found the steel reinforcement arrangements in stairs.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusions

The primary objective of this project to design a multi-story market building for Kirehe District, in line with its master plan has been successfully achieved. The architectural and structural design of the five-story modern market building in Mahama Sector met the project goals. The structural design adhered to international standards, specifically the British Standards (BS) and Eurocode, ensuring stability and global acceptability.

To ensure the structure's integrity, the internal forces that could impact the building were carefully analyzed. For the reinforced concrete design, critical structural elements were selected, including one critical slab, two critical beams in each direction, one critical column, one critical foundation, and the heavily loaded stairs. These components were designed to withstand the applied loads throughout the building's expected lifespan, providing the necessary reinforcement for stability and durability.

5.2 Recommendations

It is recommended that Kirehe District, in collaboration with investors, proceed with the implementation of this multi-story market building project. The design offers numerous benefits, including efficient land use and the establishment of durable, modern infrastructure that will serve the community for many years.

After finishing this important project, it has been observed that critical features like the electrical plan, security camera layout, cost estimation and mechanical plan were not fully taken into account. To tackle these deficiencies, it is suggested that further research will be carried out. Subsequent projects should prioritize detailed planning and design to ensure thorough integration of all necessary features. Collaboration with other researchers and field experts will be crucial to achieve a more comprehensive and well-rounded design.

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APPENDICES

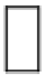
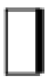
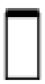
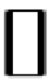
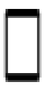
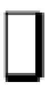
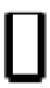
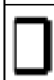
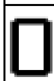
Appendix A. 1.Coefficients related to the design of members subjected to bending moment.

ξ	$\alpha_m = \frac{M}{R_b.b.h_o^2}$	η		ξ	$\alpha_m = \frac{M}{R_b.b.h_o^2}$	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
0.29	0.248	0.855		0.65	0.439	0.675
0.30	0.255	0.850		0.66	0.442	0.670
0.31	0.262	0.845		0.67	0.446	0.665
0.32	0.269	0.840		0.68	0.449	0.660
0.33	0.276	0.835		0.69	0.452	0.655
0.34	0.282	0.830		0.70	0.455	0.650
0.35	0.289	0.825		-	-	-
0.36	0.295	0.820		-	-	-

Appendix A. 2.Sectional areas of groups of bars

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	56.6	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

Appendix A. 3.Coefficients related to the design of slabs

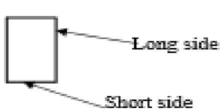
Panel	coefficients		$\lambda = \frac{L_y}{L_x}$							
			1.0	1.1	1.2	1.3	1.4	1.5	1.7	2.0
	Short side	M^-	-	-	-	-	-	-	-	-
	α_{sx}	M^+	0.037	0.044	0.051	0.059	0.066	0.072	0.083	0.095
	Long side	M^-	-	-	-	-	-	-	-	-
	α_{sy}	M^+	0.037	0.036	0.036	0.035	0.034	0.032	0.029	0.024
	Short side	M^-	0.089	0.098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

$M_{sx} = \alpha_{sx}.n.lx^2$

$M_{sy} = \alpha_{sy}.n.lx^2$

Fixed side

Pined side

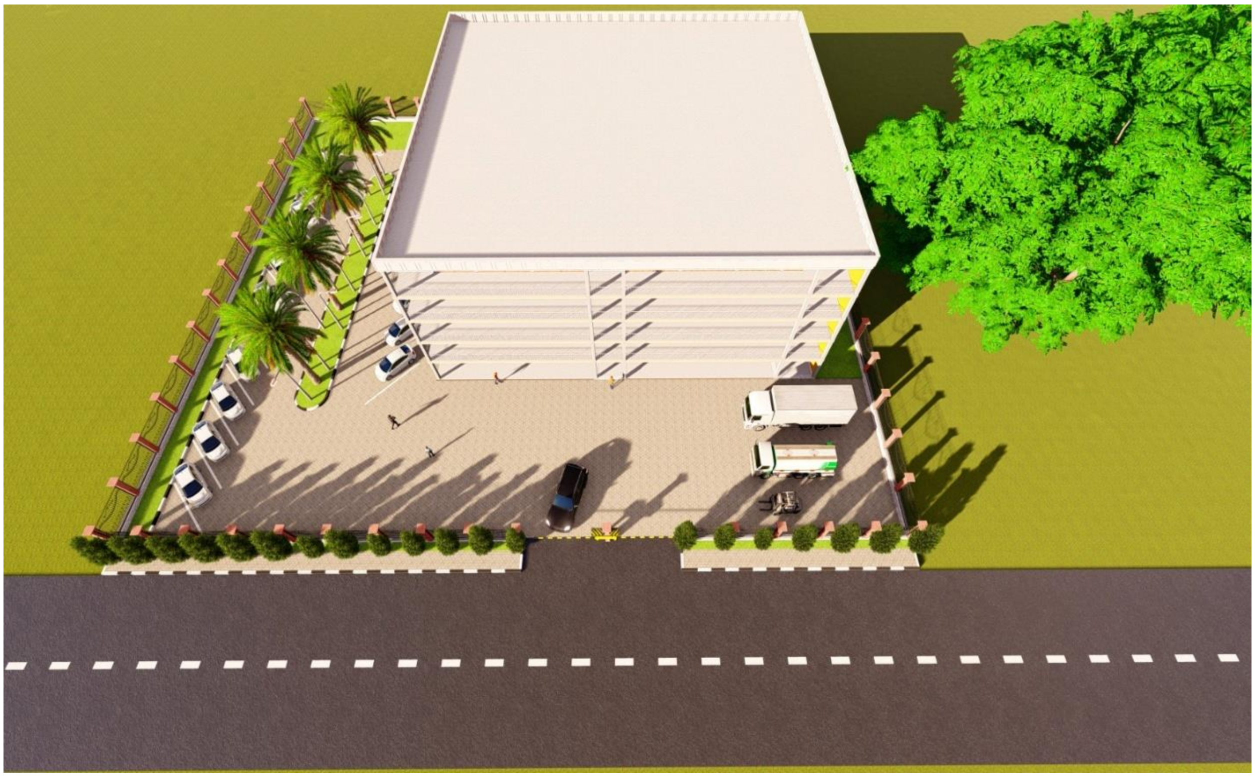


Apendix A. 4.Front view perceptive

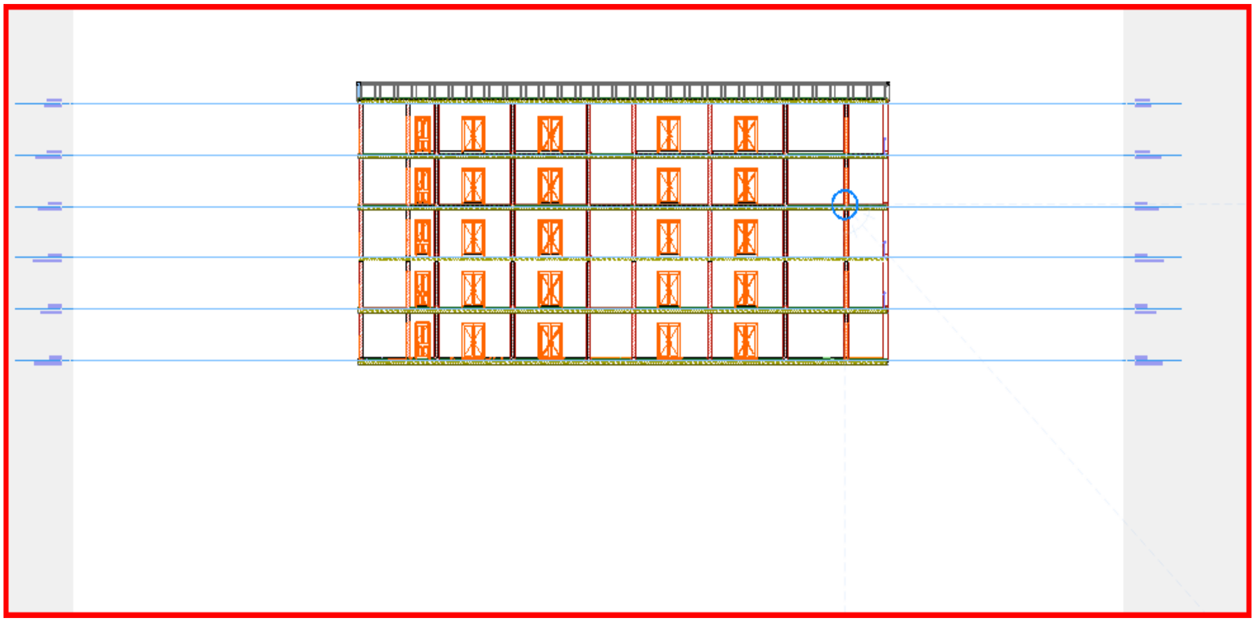
Appendix A. 5.Back view Perspective

Appendix A. 6.Left Side View Perspective

Appendix A. 7.Top View Perspective



Appendix A. 8.Elevation



Appendix A,9. Section