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DEPARTMENT OF CIVIL ENGINEERING

FINAL YEAR PROJECT

STRUCTURAL AND ARCHITECTURAL DESIGN OF HEAD OFFICES, APARTMENT AND HOTEL G+7

CASE STUDY: KIST CAMP KIGALI

Submitted in partial fulfillment of the requirement for the Award of advanced diploma

In Construction Technology

Present by:

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Under the guidance of: Eng. IRATANGA Anthere

Kigali, September 2024

DECLARATION

My name is WANY KABAGAYA, and I therefore declare that my research paper is entirely original with no submissions for academic credit towards a degree from any university or other learning institution." No portion of this study may be duplicated without permission from ULK Polytechnic Institute or the authors.

Name of student: WANY KABAGAYA

Sign: Date:

CERTIFICATE

This is to certify the project work known as **"Structural and architectural Design of head offices, apartment and hotel G+7"** is a recorded of the original work done by WANY KABAGAYA. In partial fulfillment of the requirement for the award of advanced diploma in civil engineering department, option of construction technology in ULK polytechnic during academic year 2023-2024

SUPERVISOR: Eng. IRATANGA Anthere SIGNATURE:

DATE………/ /2024

DEDICATION

This last project is dedicated to my all-powerful God.

To my friends and classmates, for your encouragement and support throughout my schooling up until this point;

To my gorgeous parents and relatives

To my supervisor for help us up to day.

ACKNOWLEDGEMENT

I am most indebted to God, the Almighty, who created and oversaw the universe, for guarding and directing each and every one of our life's journeys. I hope these few lines convey how much I admire him.

I express my gratitude to the entire personnel of ULK Polytechnic Institute, especially to the Civil Engineering department. In one way or another, their united efforts have resulted in the realisation of this work. We sincerely thank my supervisor, IRATANGA Anthere for providing us with the opportunity to work under his direction and for his technical and astute advice, recommendations, and corrections that helped to make this industrial attachment successful.

I then want to express my gratitude to my family for all of their support, care, and encouragement during my academic career. who worked hard to raise me morally and financially, and who take satisfaction in our success, and who provided for us financially from elementary school through university.

ABSTRACT

The Structural and Architectural design G+7 buildings which include hotels, apartments, and head offices are the subject of this initiative. The goal is to reduce the building's negative environmental effects while optimising energy efficiency and occupant well-being through the use of eco-friendly materials and technologies.

Important elements consist of: Sustainable Materials: Reducing reliance on conventional building materials by using bio-based composites, locally sourced lumber, and recycled materials. Energy efficiency is the use of high-performance insulation, solar panels, and passive design techniques to reduce energy use and dependency. All the chapters and other main points in this project are numbered to help those who may need to use it, to easily reach an interesting section by omitting others.

This project also has been compiled referred to various document of many authors and by using equations provided in codes of practice, with a focus on British standard (BS). The analysis begins with the evaluation of all loads that are expected to be carried by the structure including its self-weight to determine the foundation's dimensions. In the architectural design, the plans are conceived in order to show dimensions of building, and the shape of building also its height. About structural design, this project details only foundation by following BS 8110-1:1997 and BS 6399-1:1996. On the basis of the results, the detailed plans are presented.

The design criteria were conducted mainly based on British Standards (BS). The PROKON software and excel spread sheet was used for some design of member but in the most part I have been using the manually way.

Structural Design Details: 1. Slab Design: • The slab was designed with a cover of 25mm, a thickness of 30cm

• Provided reinforcement: As = 452mm² with 4T12

• The slab was evaluated for deflection and deemed satisfactory, with both maximum positive and negative moments being adequately resisted.

• No shear reinforcement was required, as the shear stress (0.3 N/mm²) was well below the shear capacity (0.38 N/mm²).

2. Beam Design: • The beam was designed with a total height of 0.75cm, aligned with ly/12 and ly/8 requirements.

• Reinforcement provided: 7T16 bars (1407mm²).

3. Column Design: • The most loaded column (C-C2) was designed as a square column with dimensions of 400mm x 400mm.

• Effective heights: 6000mm along the major axis, 3500mm along the minor axis.

• The column was classified as a braced short column.

4. Footing Design: • The footing was designed for a soil bearing capacity of 250 kN/m².

• A square footing of 1.6m x 1.6m was selected, keeping the design stress within the soil's bearing capacity.

5. Stair Design: • The stair was designed for a height of 3400mm between the ground and first floors, with a flight length of 3.3m at an angle of 27.9°.

• The design included 11 risers and 10 goings, each 3300mm in dimension.

• Moment for the flight: 30kNm. This detailed overview covers both the structural design aspects of the project, ensuring compliance with design standards while contributing to the growth of Camp Kigali's urban landscape.

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LIST OF ACCRONYMNS AND ABBREVIATIONS

Ac: total area of concrete

As max: maximum area of steel.

As min: minimum area of steel.

As prov: area of steel provided.

As req: area of tension reinforcement required at mid-span to resist the moment due to design

As: minimum recommended area of reinforcement.

Asc: area of steel in compression

Asv: area of steel in vertical links

b: width or effective width of the section or flange in the compression zone.

BS: British standard

bw: average web width of a flanged beam

COT: Construction Technology

d: effective depth of the tension reinforcement.

EP: Evening Program

fcu: characteristic strength of concrete.

fy: characteristic strength of reinforcement.

Gk: characteristic dead load.

h: overall depth of the cross-section of a reinforced member.

hf: thickness of the flange.

l: span of the beam.

lx: length of shorter side.

ly: length of longer side.

M: design ultimate moment at the section considered.

Max: moment maximum

Msx: bending moment in x direction

Msy : bending moment in y direction

Mx: moment on the column in x direction

My: moment on the column in y direction

N: design axial force.

ϕ: diameter of steel.

Qk: characteristic imposed load.

REG: Registration

ultimate loads (at support for cantilever).

V: Design shear force due to ultimate loads.

V: Shear stress.

VC: Shear capacity.

W: νsx, Vsy : design shear capacity of shear reinforcement

Z: lever arm

βsx and βsy: moment coefficients shown in Table 3.13 in BS 8110-1:1997

βsx and βsy: moment coefficients shown in Table 3.14 in 8110-1:1997

βvx and βvy: shear force coefficients shown in Table 3.15 in 8110-1:1997

γf: partial safety factor for load

γm: partial safety factor for the strength of material

CHAPTER 1. GENERAL INTRODUCTION

1.0 Introduction

The present section provides an overview of the study's history, problem statement, purpose, objectives, research question, scope, significance, and organisational structure.

1.1 Background of the study

The process of designing a structure to be both safe and useful under any load is known as structural design. The structural engineer will assess the stability, strength, and stiffness (rigidity) of the structure during this process.

Building design is the process of structural planning, requiring not only creativity and abstract thought but also a solid understanding of structural engineering in addition to practical knowledge of current design and building codes supported by a wealth of experience, intuition, and judgement. This design approach includes structural design as well as function, which work hand in hand.

The Structural design of a building's basic members and components, such as the slab, beam, columns, and footing, is the fundamental aspect of structural engineering. However, this design process is always carried out in accordance with the building plan, which depicts how the building is occupied by rooms that are both functional and comfortable for the occupants. All of these tasks are completed by according to the prescribed guidelines. Standards are meant to guarantee and improve safety while carefully balancing economy and safety.

This Structural and architectural design will take into account the use in the G+ 7 hotel, apartments, head offices. In Kiyovu cell, Nyarugenge sector, Nyarugenge district, which is the research region, all loads dead loads, imposed loads, and environmental loads will be taken into account in the design. Benefits of this topic include maximising living space by constructing multiple stories on a short plot of land, minimising building failures caused by loads, and ensuring user safety. To accomplish the goals, we continued by gathering information from a variety of sources, including literature, building businesses, standards provision, etc., and ultimately completed the design in accordance with BS 8110 and Euro Code 2.

A hotel is a type of establishment that offers short-term, paid lodging. A hotel room's amenities can vary greatly, from a small, basic room with a low-quality mattress to spacious suites with larger, better beds, a dresser, a refrigerator, and other kitchenware, as well as baths, flat-screen TVs, and upholstered chairs. Smaller, less expensive hotels might simply provide the most minimal amenities and services for visitors. Additional guest amenities like a swimming pool, a business centre with computers, printers, and other office supplies, childcare, conference and event spaces, tennis or basketball courts, a gymnasium, dining options, a day spa, and social function services can be found in larger, more expensive hotels. To make it easier for guests to identify their room, hotel rooms are typically numbered (or named in certain smaller hotels and B&Bs).

Hotel operations differ in terms of scale, purpose, intricacy, and expense. To identify hotel kinds, the majority of hotels and large hospitality companies have established industry standards. Luxurious amenities, full-service lodging, an on-site restaurant, and the best calibre of individualised care, including room service, concierge services, and ironing staff, are all provided by an upmarket full-service hotel. Upscale full-service establishments with numerous full-service rooms, an on-site full-service restaurant, and a range of on-site amenities are frequently found in full-service hotels. Smaller, independent, non-branded hotels with upmarket amenities are known as boutique hotels. Limited amenities are available on-site at small to medium-sized hotels. Small to medium-sized hotels that provide simple lodging with few or no services are known as economy hotels. Small to medium-sized hotels that provide longer-term stays are known as extended stay hotels

1.2 **Statement of the problem**

There is a shortage of land, as the population density of Rwanda makes evident. Every area of the nation's social and economic operations has evidence of it. Since residential structures are the ones that are built to house people the most, space must be conserved when they are being built. Other building forms frequently use sustainable materials in the construction of their multistory buildings.

As the art and science of understanding the behaviour of structural members subjected to loads, the structure to be constructed should primarily serve the basic purpose for which it is to be used. It also needs to have an attractive appearance and a structural design that is properly detailed to ensure that the goals of serviceability, durability, elegance, economy, and safety of structures are met. In order to effectively convert natural resources for human benefit, engineering, as a professional art, requires creative imagination to come up with novel and useful applications for natural phenomena.

All loads applied to the structure, such as compressive stresses, tensile stresses, shear stresses, etc., must be resisted without failure for the duration of the structure's life.

1.3 **Purpose of the study**

In keeping with Rwanda's goal of demonstrating modern infrastructure, the study's objective is to perform the structural and architectural design of head offices, apartments, and hotels G+7. Additionally, this project aims to support Kigali, particularly in the Nyarugenge sector, in providing adequate affordable housing and well-equipped living spaces. As such, residents should be advised on how to live in a hotel block that conserves space. This project also fulfils the goals of NST 1.

1.4 **Objective of the study**

This study's primary goal is to provide the construction procedures, architectural specifications, and technical requirements for creating a multi-story office, residential, and hotel building with all of the structure's requirements met by qualified engineers.

1.4.1 Specific objectives

The following were the project's specific goals:

a) To ascertain the architectural drawing of the G+7 hotel, apartments, and head offices.

b) To calculate the bill of quantities for the suggested green construction of the G+7 hotel, apartments, and head offices.

1.5 **Scope and limitation of the study**

The primary focus of the project is demonstrating the structural and architectural design of the green head office, apartment block and hotel G+7 in the Nyarugenge sector.

Only a limited amount of geotechnical work, such as soil testing, could be completed in the allotted period. Secondary data will be used to determine the soil's carrying capacity. Electrical design was limited, just like plumbing, drainage systems, septic tanks, electrical installation, and cost estimation. Structural element design, including slab, beam, column, stairs, and footing, will be covered in this final year project. This project's calculation will be thoroughly explained, with an emphasis on area reinforcement. It will also cover the B.Q. preparation.

1.6 Significance of the study

The successful completion of the advanced diploma in construction technology is mostly attributable to this study's contribution to the transition from theory to practice. Following an improvement in research knowledge and abilities related to structural design, proficiency with engineering software such as AutoCAD, Archi CAD 24, and proto-structure will be beneficial. The most important engineering courses, including RCD I and II and Structural Analysis I and II, will be covered.

Academically, this project research will serve as a guide for students and other individuals who wish to build, ensuring that the surrounding population lives in a safe and healthy environment thanks to high-quality housing.

1.7 **Organization of the study**

There are five chapters in this work, the general introduction being the first one. The introduction, background, problem statement, objectives, significance, , scope, and organisational style of the study are all included. The second chapter will contain the literature review, which will go over the general understanding of the related studies. The third chapter, which covers research technique, will focus on the strategy and tools to be used to achieve the objectives of the study. The fourth chapter—titled "Result and Discussion"—which presents the findings—will be the most important one. The fifth and last chapter will provide a conclusion and recommendations on the predetermined goals.

CHAPTER 2. LITERATURE REVIEW

2.1 Definitions

2.1.1 Structural Design:

Structural design is a sub-discipline of civil engineering, which deals with the design of a robust and usable structure. Depending on the goals of the building project, they may also work with architects to create a unique, visually appealing design think the Eiffel Tower.

2.1.2 Reinforced concrete

A fluid slurry that is simple to pour and shape is created when aggregate, water, and dry Portland cement are combined. Through a process known as "concrete hydration," the cement and water combine to form a strong matrix that binds the ingredients together to create a long-lasting substance with multiple applications. This process takes many hours to complete. At this time, concrete can be mixed as well as cast.

Ferroconcrete, another name for reinforced concrete, is a composite material in which reinforcement with a higher tensile strength or ductility is added to concrete to make up for its relatively low tensile strength and ductility. The reinforcement is often passively implanted in the concrete before it cures. It need not always be steel rods, or rebar. But post-tensioning is also used as a concrete reinforcement technique.

It is one of the most widely utilised engineering materials in terms of yearly volume utilised. To use the language of corrosion engineering, properly built concrete's alkalinity shields the steel rebar from rust. The following materials can be used to make reinforced concrete. (Neville & Brooks, 2010).

2.1.2.1 Concrete

A composite material known as concrete is made up of aggregate joined together with a fluid cement that eventually solidifies. Concrete is the most often used building material and the second most used material globally, after water. Tonne for tonne, its global utilisation is double that of aluminium, steel, wood, and plastics put together.

A fluid slurry that is simple to pour and shape is created when aggregate, water, and dry Portland cement are combined. Through a process known as "concrete hydration," the cement and water combine to form a strong matrix that binds the ingredients together to create a long-lasting substance with multiple applications. This process takes many hours to complete. At this time, concrete can be mixed as well as cast. (Mindess, Young, & Darwin, 2003).

strength classes of concrete		
Class	F_{ck} (N/mm^2)	Normal lowest class for use as specified
C 16/20	16	Plain concrete
C 20/25	20	Reinforced concrete
C 25/30	25	
C 28/35	28	Pre-stressed concrete/Reinforced concrete subjected to chlorides Reinforced concrete in foundations
C 30/37	30	
C 32/40	32	
C 35/45	35	
C 40/50	40	
C 40/55	45	
C 50/60	50	

Table 2 1 strength classes of concrete

1. Cement:

The most often used type of cement is Portland cement. It is a fundamental component of many plasters, mortar, and concrete.[40] It is made up of a combination of chemicals that will react with water, including aluminates, ferrites, and calcium silicates (alite, belite). In order to make Portland cement and related materials, limestone, a calcium source, is heated along with clay or shale, a source of silicon, aluminium, and iron. The resulting product, known as clinker, is then ground together with a sulphate source, usually gypsum.

Cement kilns are huge, intricate, and naturally dusty industrial structures. The most energy-expensive element among the mixtures needed to make a specific amount of concrete is cement. A tonne of product requires 3.3 to 3.6 gigajoules of energy, even in sophisticated and effective kilns. (Hewlett, 2004).

2. **Curing**:

Hydration is the process by which cementitious materials and water combine to make cement paste. The aggregate is held together with cement paste, which also fills in gaps and improves flow.

According to Abrams' law, a concrete with a lower water-to-cement ratio is stronger and more resilient, while a concrete with a higher slump is more freely flowing and has more water. Numerous simultaneous events occur during cement hydration. Polymerisation, the silicate and aluminate components' interlinking and connecting to sand and gravel particles to produce a solid mass, are all steps in the process. The following conversion serves as an example: tri-calcium silicate is hydrated. (Hewlett, 2004).

a) Chemical nomenclature for cement: C3S + H → C-S-H + CH + heat

b) Conventional notation: $Ca3SiO5 + H2O \rightarrow CaO \cdot SiO2 \cdot H2O$ (gel) + Ca(OH)2 + heat

c) 2 Ca3SiO5 + 7 H2O → 3 CaO・2 SiO2・4 H2O (gel) + 3 Ca(OH) in balance.2 + heat (roughly, since the precise proportions of CaO, SiO2, and H2O in C-S-H can change) Cement cures, or hydration, is an irreversible process .

3. **Aggregates**:

The majority of a concrete mixture is composed of fine and coarse particles. The most common materials used for this are crushed stone, sand, and natural gravel. While a variety of manufactured aggregates, such as air-cooled blast furnace slag and bottom ash, are also allowed, recycled aggregates—derived from construction, demolition, and excavation waste—are increasingly being utilised as partial substitutes for natural aggregates. The amount of binder needed is determined on the aggregate's size distribution. The largest gaps are seen in aggregate with a relatively equal size distribution; these gaps are often filled by adding aggregate with smaller particles.

The binder, which is usually the most expensive component, is required to both paste the aggregate surfaces together and fill the spaces between the aggregate. Consequently, variance in aggregate size lowers the price of concrete. The use of aggregate does not adversely affect the strength of the concrete because it is almost usually stronger than the binder. Vibration's influence frequently results in non-homogeneity when aggregates are redistributed following compaction. Gradients in strength may result from this. (Kosmatka, Kerkhoff, & Panarese, 2002).

4. **Admixture**:

Additives are substances, either in powder or liquid form, that are mixed into concrete to give it specific properties that aren't possible with standard concrete combinations. Additions "made as the concrete mix is being prepared" are referred to as adjuvants. Accelerators and retarders are the most often used admixtures. Admixture dosages are typically applied to the concrete during batching or mixing and are less than 5% by mass of cement. (See below under § Production.) The following are typical admixture types:

a) Accelerators hasten the concrete's hydration, or hardening. Calcium chloride, calcium nitrate, and sodium nitrate are common materials. While nitrates are less effective than chloride salts, their usage may be preferred because chlorides can cause corrosion in steel reinforcement and are banned in some countries. In colder climates, accelerating admixtures are particularly helpful for changing the characteristics of concrete.

b) Tiny air bubbles are introduced and entrained into the concrete by air entraining agents, which increases durability by minimising damage during freeze-thaw cycles. Entrained air, however, comes with a strength trade-off, as each 1% of air might result in a 5% reduction in compressive strength. Defamers can be used if excessive air is trapped in the concrete during the mixing process.

c) Bonding agents, which are usually polymers with a broad temperature tolerance and corrosion resistance, are employed to form a link between old and new concrete.

d) Steel and steel bars in concrete are protected against corrosion by the use of corrosion inhibitors.

e) To reduce permeability, crystalline admixtures are usually applied when the concrete is being batch-produced.

f) When water and hydrated cement particles are combined, a reaction occurs that produces insoluble needle-shaped crystals that plug capillary pores and micro cracks in the concrete, obstructing the flow of water and other contaminants.

g) Concrete that has a crystalline admixture added to it should self-seal since water exposure over time will cause crystallisation to occur repeatedly, providing long-lasting waterproofing.

h) For aesthetic purposes, concrete can have its colour changed with the use of segments.

i) Plasticisers make plastic concrete, or "fresh" concrete, more workable so that it may be laid more quickly and with less effort required to consolidate. The plasticiser lingo-sulfonate is a common one. Plasticisers, sometimes known as water-reducers because of this application, can be used to lower a concrete's water content without sacrificing workability. Its durability and strength properties are enhanced by this treatment. (Mehta & Monteiro, 2014)

5. Mineral admixture and blended cement

These extremely fine-grained inorganic minerals, known as mineral admixtures, are added to the concrete mixture to enhance its qualities (mineral admixtures) or to take the place of Portland cement (blended cements). Products that are being evaluated and utilised contain fly ash, limestone, blast furnace slag, and other beneficial minerals having pozzolanic qualities.

These advancements are becoming more and more important in reducing the effects of cement consumption, which is infamous for producing between five and ten percent of the world's greenhouse gas emissions.

The construction industry's circular economy is becoming more and more important, with ever-increasing demands on waste generation, landfill practices, and raw material extraction. Using alternative materials can also reduce costs, improve the properties of concrete, and recycle wastes. a) Fly ash, a byproduct of coal-fired power plants, can replace Portland cement up to 60% of the mass in some applications. The type of coal burned determines the characteristics of the fly ash. Whereas calcareous fly ash possesses latent hydraulic properties, siliceous fly ash is typically pozzolanic.

b) Ground granulated blast furnace slag, often known as GGBS, is a byproduct of the steel industry that may replace up to 80% of the mass of Portland cement. Latent hydraulic properties are present.

c) A by-product of the synthesis of silicon and ferrosilicon alloys is silica fume. Fly ash and silica fume are comparable, however silica fume has particles 100 times smaller. As a result, the pozzolanic reaction proceeds significantly more quickly and the surface-to-volume ratio rises. Concrete that has been treated with silica fume is stronger and more durable, although it usually needs to be worked with superplasticizers.

d) High reactivity metakaolin (HRM): Metakaolin yields concrete that is almost as strong and durable as silica fume-made concrete. High-reactivity metakaolin is typically dazzling white in colour, which makes it the preferable option for architectural concrete where appearance is crucial, whereas silica fume is typically dark grey or black in colour.

e) Concrete can benefit from the addition of carbon nanofibers to increase its Young's modulus, compressive strength, and electrical characteristics, all of which are necessary for strain monitoring, damage assessment, and self-health monitoring. Because of its high tensile strength and high electrical conductivity, carbon fibre offers numerous benefits in terms of mechanical and electrical qualities (such as increased strength) and self-monitoring behaviour.

f) To make concrete electrically conductive for dicing, carbon products have been added.

g) According to recent research from the University of Kitakyushu in Japan, utilising a recycled mix of used nappies that has been cleaned and dried can help reduce the amount of waste that ends up in landfills and the amount of sand necessary to make concrete. In order to evaluate the strength and longevity of the novel diaper-cement composite, a model house was constructed in Indonesia. (Hewlett, 2004).

2.1.2.2 Reinforcing steel bar

Steel reinforcement is the term for the steel wires and bars that give concrete strength and stability. These bars and wires are made especially for the construction sector and are intended to be used with concrete. Specifications for steel reinforcement, such as size and chemical composition, have been established by the IS Code.

A steel bar, sometimes called a tone bar, slide bar, guitar slide, bottleneck, or simply "steel," is a smooth, hard object that is pressed up against the strings to play steel guitar. The name "steel guitar" comes from this practice.

A steel bar, sometimes called a tone bar, slide bar, guitar slide, bottleneck, or simply "steel," is a smooth, hard object that is pressed up against the strings to play steel guitar. The name "steel guitar" comes from this practice. The gadget can be worn around the player's finger or it can be a solid bar that is held in the hand. The steel guitarist uses one of these objects pressed against the strings with one hand, while plucking the strings with the other, to gain the ability to play a smooth glissando and a deep vibrato that are not possible when playing a traditional guitar. (Gambhir, 2014)

Figure 2 1 Steel reinforcing bar

Properties	Concrete	Steel
Strength in tension	Poor	Good
Strength in compression	Good	Good but slender bars will buckle
Strength in shear	Fair	Good
Durability	Good	Corrodes if unprotected
Fire resistance	Good	Poor-suffers rapid loss of strength at high temperatures

Table 2 2 Comparison between concrete and steel (Neville, 1995)

Steel structures and reinforced concrete work well together, a combination known as composite construction that takes advantage of each material's advantages.

The use of steel beams or columns embedded within reinforced concrete elements is one typical application for this combination. Strength and stability are provided by the steel components, and stiffness, fire resistance, and corrosion protection are added by the reinforced concrete around them.

2.2 **Structural design**

It is a technique or instrument that helps us determine the cost-effective and safe specifications of a construction or a structural part that is strong enough to support the weight.

To put it another way, determining the cross-sectional dimension, material grade, amount of reinforcement, etc. required to withstand the internal stresses that our structural study has shown. The main components of a concrete building frame are as follows:

a) large-area slabs; b) beams for supporting slabs and walls; c) columns for supporting beams; and d) footing to disperse concentrated column loads over a substantial portion of the supporting soil so as not to exceed the soil's bearing capacity.

2.3 **Design methods**

Three fundamental techniques have been created that use safety factors to create safe, practical structures:

a) The allowable stress method, which divides the ultimate strengths of the materials by a safety factor to produce design stresses that are typically within the elastic range.

b) The load factor approach, which multiplies the operating loads by a safety factor.

c) The limit state approach, which divides the ultimate strengths of the materials by additional partial factors of safety and multiplies the working loads by partial factors of safety.

2.3.1. Permissible stress method

Although the allowable stress approach has shown to be a straightforward and helpful technique, there are several significant discrepancies in it. It is not truly applicable to a semi-plastic material like concrete because it is based on an elastic stress distribution, nor is it appropriate in situations where the deformations are not proportionate to the load, like in thin columns. Additionally, it has been shown to be dangerous when addressing the stability of structures vulnerable to overturning pressures.

2.3.2. Load factor method

The ultimate strength of the materials should be utilised in the calculations when using the load factor approach. This method cannot directly account for the variability of the materials since it does not apply safety factors to the material stresses. Moreover, it cannot be utilised to compute deflections or cracking at operating loads.

2.3.3. Limit state method (Korabu, 2006)

A structure's design goal is to attain reasonable odds that it won't approach a limit state, or become unsuitable for the application for which it was intended.

Therefore, a limit state is any circumstance in which a building could become unusable, and the goal of design is to prevent this from happening at any point within the structure's anticipated lifetime. The two principal types of limit state are the ultimate limit state and the serviceability limit state.

a) Ultimate Limit State

Should consider a number of criteria, including the load and the strength of the material. Separate partial factors are applied for material and load. The letters M stand for load safety factor and material.

Design strength is equal to characteristic strength (fy) / partial factor of safety (rm).

b) Serviceability Limit States

In general, these are the states with the highest serviceability limits:

1. Diversion: deflections must not negatively impact any component of the structure's efficiency or appearance.

2. Breaking: localised cracking and spalling damage cannot compromise the structure's strength, functionality, or beauty.

3. Sturdiness: this needs to be taken into account with the structure's anticipated lifespan and exposure circumstances.

4. Excessive vibration, which can be damaging as well as uncomfortable or alarming

5. Exhaustion must be taken into account if cyclic loading is probable.

6. Resistance to fire, heat transfer, flame penetration resistance, and collapse resistance must all be taken into account.

2.4 Partial factors of safety (rm) (Korabu, 2006)

Should take into consideration many factors such as material strength, load, etc. For material and load, separate partial factors are applied. M stands for material and load safety factor.

Characteristic strength (fy) / partial factor of safety (rm) equals design strength. The following lists the partial safety factors for materials that will be multiplied by their characteristic strength;

Material	Limit state		
	Collapse	Deflection	Cracking
Concrete	1.5	1.0	1.3
Steel	1.15	1.0	1.0

Design strength $fm = \frac{fck \text{ or } fy}{\gamma m}$

Table 2 3 Values of portal safety factor

2.5 **Design loads**

Generally speaking, the term "design load" refers to the highest quantity that a system is intended to manage or the highest quantity that the system is capable of producing—two rather different concepts. A crane with a 20-ton design load, for instance, is made to lift objects weighing 20 tonnes or fewer. However, a safety factor is required when a failure could be disastrous, like in the case of a crane losing its weight or completely collapsing. Therefore, the crane should be able to lift a maximum of 2 to 5 tonnes.

A design load in structural design is higher than the load that the system is anticipated to support. This is due to the fact that engineers include a safety factor in their design to guarantee that the system can withstand at least the anticipated loads (also known as specified loads), regardless of any undiscovered issues with materials, construction, etc.

A heater's maximal heat-producing capacity is known as its general design load. A bridge would have a stated load, and the design load would be applied as a theoretical load meant to guarantee the actual real-world capability of the given load, which would be decided by engineers. The following formula is used to compute the design load (Smith, 2016):

a) Column= Self weight* number of storeys

b) Wall load per running metre;

c) Beams equal self weight;

d) Total load on slab (self load plus dead load plus live load plus wind load).

1. Load on Column calculation

Self weight of concrete is about 2400kg/m^3 which is about 24.54kn/m^3

Self weight of steel is about 7850kg/m^3

If the column size is 300mm * 600mm with 1% steel and 2.55 high, the self weight of the column is about 1000 kg per floor or 10kN.

2. Load on Beam calculation

If a beam is 300mm*600mm excluding slab thickness thenn300mm*600 excluding slab

Volume of concrete = 0.30* 0.60*1 =0.18^3

Weight of concrete = 0.18* 2400= 432kg

Weight of steel (2%) in concrete = 0.18*2*7850=28.26

Total weight of beam = 432 + 28.26= 460.26kg/m = 4.51KN/m

3. Load on wall calculation

Density of bricks = 1800 to 2000 kg/m^3

For 9 inch thick brick or 230mm brick wall od 2.55meter height and a length of 1 meter, the calculation is as follows:

The load= 0.230*1*2.55*2000=1173kg/meter or 11.50kN/meter

4. Load on slab calculation

If the slab is 15mm thick, self weight= 0.150*1*2400 = 360kg or 3.53kN

Let the food finishing load be 1kN per meter superimposed live load to bw 2kN meter and lastly the wind load is 875 near about 2kN meter. The slab load hence is about 8 to 9kN per sq mt.

The design load formula is indeed confusing so let experts handle it if you are not pro at it.

2.5.1 Dead load

The term "dead loads" refers to the loads resulting from permanent building materials, such as claddings, finishes, and fixed equipment that make up the roof, floor, wall, and foundation systems. Table 3.2 lists the values for dead loads for popular materials and constructions found in light-frame residential buildings. Values for typical material densities are shown in Table 3.3, which could help with more precise dead load calculations. The easy way to calculate dead loads is illustrated by the design examples in Section 3.10. Dead load is determined using (Smith, 2016) :

1. Dead load is equal to member volume times material unit weight.

2. The total dead load can be calculated by adding the various parts.

Material	Density (kg/m^3)	Unit weight (kg/m^3)
Concrete	2300	25
Steel	7750-8050	78.5
Bricks	1600-1920	16-19.2
Timber	1520	6

Table 2 4 typical unit weight for construction materials

2.5.2 **Live load**

The occupancy and use of a building generate live loads. Human occupants, furniture, non-fixed equipment, storage, and construction and maintenance activities are examples of loads. Recommended design live loads for residential buildings are shown in Table 3.4. Use of those loads, together with the load combinations listed in Table 3.1 and other parameters covered in this part, is demonstrated in part 3.10's Example 3.1. Loads are expressed in terms of uniform area loads (psf), concentrated loads (lbs), and uniform line loads (plf), as necessary to appropriately define the loading condition. In a structural evaluation, the concentrated and uniform live loads shouldn't be applied at the same time. In order to achieve the greatest load effect under end-use conditions, concentrated loads should be placed on a limited area or surface that is compatible with the application. For instance, the 300-pound stair concentrated load ought to be delivered between the supports at the middle of the stair tread.

All sections or members subject to a wheel or jack load should have the concentrated wheel load of a vehicle on a garage slab or floor applied to them. Typically, a loaded area of roughly 20 square inches is used. (Smith, 2016)

2.5.3 Wind load

Wind generates wildly fluctuating non-static stress on a structure. The complexity of the variations in pressures at various places on a building can make pressure analysis too involved for accurate design consideration. Consequently, wind load requirements take into account fundamental static pressure zones on a building that are indicative of peak loads that are expected to be experienced in an effort to simplify the design problem. However, for a given wind direction, the peak pressures in one zone might not coincide with the peak pressures in other zones. The peak pressure in various pressure zones is dependent on a small range of wind directions. Therefore, in order to determine risk-consistent wind loads on buildings, the wind directionality effect must also be taken into account. Actually, in determining nominal design loads in some streamlined form, the majority of contemporary wind load standards consider wind directionality and other influences (SBCCI, 1999; ASCE, 1999). In order to offer a simple yet efficient method for designing typical residential buildings, this section further simplifies wind load design parameters. (Smith, 2016)

The following will determine this: a) The angle at which the wind hits the building.

b) The structure's shape, including its height and width

c) The structure's dimensions.

d) Mounting objects such as antennae atop structures.

e) Wind load estimates are necessary for the design and construction of safer and more wind-resistant buildings

CHAPTER 3. RESEARCH METHODOOGY

3.0 **Introduction**

This chapter covers the approaches that will be employed and provides a thorough explanation of the methodology for this study. We'll be talking about methods and instruments for gathering data, which will be examined before being put to use. Data gathering strategies such as documentation, data collection from various sources (e.g., Eurocodes standards, design documentation, methodological data (e.g., rainfall, wind speed), consultation with design offices, etc., will be employed in this research in order to obtain sufficient information.

3.1 Type of data

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

3.1.1 Primary data

These were taken straight off of the architectural blueprint. They will be carried out by taking measurements of the various member and structural member dimensions from the plan. The dimensions used for these measurements will be diameter, thickness, width, and height. It will be possible to obtain more data from these direct measurements. These will comprise the area and volume calculations. (Smith, 2016)

3.1.2 Secondary data

They were gathered from the pre-existing record. Their source must always be cited when they are used. Standard provision, the surrounding environment, and the local climatic conditions (rainfall, wind speed, earthquake magnitude, etc.) will all be included in these statistics. Additional information will be taken from standard provisions, which are accessible based on the circumstances surrounding the design. (Smith, 2016)

3.2 **Description of the study area**

Kiyovu cell, Nyarugenge sector, Nyarugenge district, Kigali City is the study's location. This was decided upon in order for the project to benefit Kigali City's growing population on a daily basis once it is put into action. Following the location of the area of usage during design, the region's geographical location must be displayed

Figure 3 1 Location of the plot of the study area

3.3 Site visit of study area

An analysis of the area and region is crucial for any design to be both safe and cost-effective. The condition of the site where the new structure must be built will be studied with the goal of determining the project's proper location in relation to its neighbours, the best accessibility options, the topography of the site, past uses of the site, the project's suitability for the area, etc. These factors will form the basis of the design. We have enumerated our observations along with our preferred designs as we visit the site for these purposes.

3.4 **Design assumptions**

When the following presumptions stated in EN 1990 are met, a design that makes use of the principles and application guidelines is considered to have complied with the requirements:

a) In order to fulfil the characteristic strength value, adequately skilled and experienced individuals choose the structural system and design the construction.

b) Personnel with the necessary training and expertise carry out the execution.

b) The work is executed with sufficient supervision and quality control.

d) The product and building materials are employed in accordance with EN 1990, EN 1991, and EN 1992 specifications, or with the applicable execution requirements.

e) Throughout the duration of its design life, the structure will get proper maintenance.

f) The arrangement will be utilised in compliance with design assumption.

3.5 Requirements directing the design (EN 1990-2002)

3.5.1 Architectural requirement

The structure that is to be built must appear well and principally fulfil the fundamental function for which it is intended. Both inside and outside the building, a joyful atmosphere is required. Consequently, a building's function planning will consider factors such as appropriate room arrangements that meet user needs, appropriate lighting, ventilation, and acoustics, an unhindered view, enough headroom, an appropriate water supply and drainage system, landscaping the surrounding area, including planting trees, and so forth. These elements will be taken into consideration when developing the complex apartment's architectural plan.

3.5.2. Structural requirements

1. A building must be planned and built such that it can withstand all actions and influences that are anticipated to occur during construction and use, sustain all of these effects for the duration of its intended life, and continue to be suitable for the intended use.

2. The structural resistance, serviceability, and durability of a structure must be considered during its design.

3. In the event of a fire, the structural resistance will be considered sufficient for the necessary amount of time.

4. The design and implementation of a structure must ensure that it is not subjected to damage disproportionate to the initial source, such as explosions, impacts, and human errors

5. Potential harm must be prevented or minimised by making the right decision regarding one or more of the following:

a) Reducing, removing, or avoiding the risks that the structure may encounter.

b) Choosing a structure that is less susceptible to the risks under consideration.

c) Steering clear of structural systems that are susceptible to sudden collapse.

d) Choosing a structural material and design that can withstand acceptable localised damage or the unintentional removal of a single or a small portion of the structure.

f) Fastening the structural elements collectively

6. The selection of appropriate materials, proper design and details, and the specification of control processes for design, manufacture, execution, and use pertinent to the specific project are all necessary to meet the structural criteria.

3.5.3 Durability requirement

a) The structure must be built with consideration for its surroundings and the expected degree of maintenance, so that deterioration during the course of its intended working life does not reduce the building's intended performance.

b) The intended or anticipated use of the structure, the necessary design criteria, the anticipated environmental conditions, the composition, performance, and qualities of the materials and product, the properties of the soil, and the required design criteria in order to build an appropriately durable structure.

c) The environmental conditions were determined during the design phase, allowing for the appropriate protection of the structure's materials and an assessment of their relevance in terms of durability.

Parameter	Value	Reference
Design situation	Persistent situations corresponding to normal conditions of the structure	EN 1992-1-1:1992, clause 2.2.1.2
Design working life	50 years	EN 1991-1-1:2002, Table 2.1
Categories of use of buildings	Category A	EN 1991-1-1:2002, Table 6.1
Imposed loads on floors, balconies and stairs in the building of category A	$4KN/m^2$	EN 1991-1-1:2002, Table 6.2
Roof category	Category H	EN 1991-1-1:2002, Table 6.9
Load imposed on roof of category H	$1.5KN/m^2$	EN 1991-1-1:2002, Table 6.10
Density of plain concrete	$24KN/m^3$	EN 1991-1-1:2002, Table A.1
Density of concrete	$25KN/m^3$	EN 1991-1-1:2002, Table A.1
Density of concrete based masonry	$21KN/m^3$	EN 771-3
Density of stone masonry	$27KN/m^3$	EN 1991-1-1:2002, Table A.1
Combination of action for persistent design situation	$\Sigma Y_{G,J}G_{K,J}+\gamma_{Q,1}Q_{K,1}+$ $\Sigma\gamma_{Q,i}$¥$_{Q,i}Q_{K,i}$	EN 1992-1-1:1992, clause 2.3.2.2
Partial safety factors for action on building structures	1.0 for permanent actions ($_\gamma$G)	EN 1992-1-1:1992, Table 2.2
Partial safety factors for concrete γC	1.5	EN 1992-1-1:1992, Table 2.3
Horizontal loads on partition walls and parapets for buildings in category A	0.5KN/m	EN 1991-1-1:2002, Table 6.12

Table 3 1 Standards provision to be used in design

Same helpful information conducted to be used in design of multi-purpose buildings are the following:

Factor of safety for live load= 1.6

Factor of safety for dead load= 1.4

Concrete cover= 25mm

Floor-imposed load (maximum)= 5KN/m^2

Partition= 1KN/m^2

Stairs imposed= 5KN/m^2

Self-weight of Finishes= 19KN/m^3

Offices live loads= 5KN/m^2

Concrete grade: F_{cu}= 30KN/m^2

Reinforcement: F_y= 460KN/m^2

For stirrup= 250N/mm^3

Self-weight of reinforced concrete= 25KN/m^3

Self-weight of Masonry= 22KN/m^3

Bearing capacity= 250KN/m^2

3.6. Analysis method

Is a set of technic or critical calculation that allows engineers for analysing different structural elements, this method is used without application of software and it was used for columns, foundation, and stairs(Schneider, 2006)

3.6.1 Some formulas to use in this building project

3.6.1.1. Design of slab

Slab is horizontal, flat structural element is provided as a cover floor of the building. Slab support different loads such as its self weigh and imposed loads.

Thickness of slab lies between Lx/20 and Lx/40 where Lx is the shorter side of the panel, using the bigger panel among others.

The effective height (ho)= thickness of the slab (h_f) – the clear cover (mosley, et al 2007).

I. loads on slab

a) Dead load

Total dead load= self-weight of the slab + finishes

Self-weight of the slab= thickness of the slab × 1.4 × unite weight × breath of slab (1m)

Finishes= 1.4 × unit weight of finishes × breath of the slab

b) Live load

Live load= 1.6 × live load from tale BS6399: 1-1996

Design load= design dead load of + design live load

II. Types of slab

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

l_y= long side

l_x= short side

III. Bending moment

$\mathbf{M_x = \alpha s_x \times N \times lx^2}$

$\mathbf{M_y = \alpha s_y \times N \times ly^2}$

Where M_x= moment a long side and M_y= moment a short side

as_x, αs_y= coefficients related to the sign of slab

N= total load on slab

Lx= short side of slab

IV. Shear force

$\mathbf{Vs_x = \alpha s_x \times N \times l_x^2}$

$\mathbf{Vs_y = \alpha s_x \times N \times l_y^2}$

V. Requirement steel reinforcements

$\alpha_m = \frac{M}{Rbho2b}$

Where, αm= coefficient related to the design of member subjected to bending moment

R_b= design concrete compression strength

b= width of compression area

h_o= effective height

m= can be positive or negative, if m is positive means that moment is at bottom , but if m is negative means that moment is at top.

$As = \frac{M}{\eta Rsho}$

Where, As= total cross section of steel reinforcement

Rs= design steel tensile

h_o= effective height

η= coefficient related to the design of members subjected to bending moment

VI. One way slab

a) Moment and shear force

b) Calculation

The coefficient of moment and shear fore are found in table 3.12 of the code (BS8110:1-1997)

	End support/ slab connection				At first interior support	Middle interior span	Interior support
	Simple		Continuous				
	At outer support	Near middle of end span	At outer support	Near middle of end span			
Moment	0	0.086F	-0.04 FL	0.075FL	-0.086FL	-0.063FL	-0.063FL
Shear	0.4F	-	0.46F	-	0.6F	-	0.5F

Table 3 2 Ultimate bending moment and shear force in one way spanning slab

3.6.1.2. Design of beam

Beam is horizontal structural element of the building which resists load applied laterally to its length.

I. Computation of the depth of the beam

$\frac{lmax}{12} \leq \mathbf{h} \leq \frac{lmax}{8}$, where Lmax is the largest span between two consecutive beams

II. Computation of web of flange pf the beam(b_w)

$\mathbf{0.5} \leq \frac{lmax}{h} \leq \mathbf{1}$**,** where bw is the web of flange of the beam

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

Plater on the wall= safety factor × thickness of finishes × (length + width of influence area) × φ unit weight.

III. Live load

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

IV. Breath of beam

$\frac{h}{3} \leq b_w \leq \frac{h}{2}$

3.6.1.3. Design of column

A column is a vertical structural element that support loads from roof floor and transmit them to the foundation.

Code classified column in to two types: Short column and lender column

- Short column is when Lex/h and Ley/h is less than 15 for braced column and less than 10 for unbraced column.

Le_x= Effective height with respect to major axis

Le_y= Effective height with respect to minor axis

H= width of column

B= breath of column

Le= Bl_o, where B= coefficient that depends on end condition(condition 1, 2, 3, 4)

Lo= height of the column $0.75 \leq B \leq 1$

Table 3.19 and table 3.20 shows the value of B for braced column and unbraced column respectively. In order to control cracking in the column B should be dependent to $\frac{N}{bhfcu}$ this value is found in table 3.22 of bhf_{cu} the code.

Minimum renforcement: $\mathbf{As_{min}} = \frac{0.4 \times Ac}{100}$

Maximum renforcement: $\mathbf{As_{max}} = \frac{6 \times Ac}{100}$

I. Links/stirrups

The diameter of links should not be less than 6mm or a quarter of maximum diameter of main bar

The spacing of links should not be greater than 12times the maximum diameter of main bar.

II. Design of short column

- Design of short column subjected to **N= 0.45f_{cu}Ac + 0.95f_yAc**
- Design of short column subjected to axial lad and moment on one axis.
- Design chart are used: **on y axis=** $\frac{N}{bh}$

On x axis= $\frac{M}{bh2}$, $\frac{100Ac}{bh}$= the value from chart

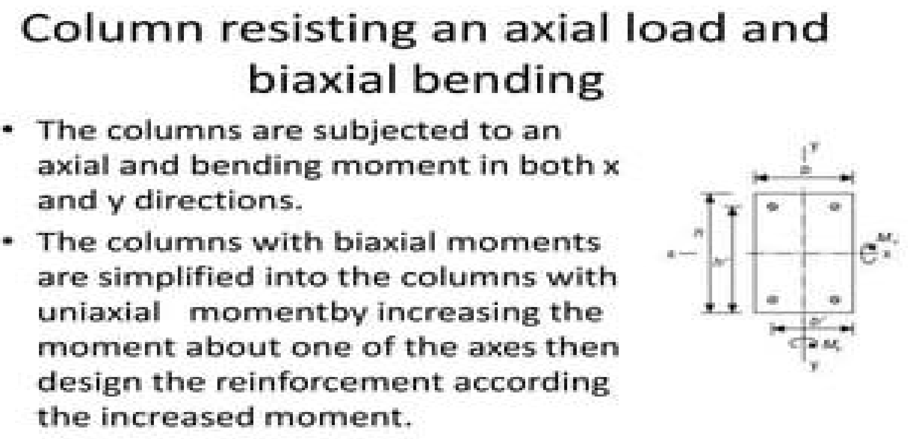


Figure 3 2 Design of short column subjected to axial lad and biaxial moment

$\frac{Mx}{h'} > \frac{My}{b'}$ **,** the increase moment is $\mathbf{M_x= M_x + \frac{\beta b'}{b'} M_y}$

If $\frac{My}{b'} > \frac{Mx}{h'}$, the increase moment is $\mathbf{M_y= M_y + \frac{\beta b'}{h'} M_x}$

a) Load applied on the floor of the column

1) **Under- ground part of the column**

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

Loads= (load from the slab + masonry load and the plaster on the wall + live load from the slab + self-weight of the column) × number of storeys + (load from beam × number of storeys + 1) + (self- load of the underground column)

2) **Ground floor part of the column**

Load= (dead load from the slab + live load from the slab + load from the beam + self-weight of the column) × number of the floor + (load from wall and their plaster) × (number of floor – 1)

3) **Steel reinforcement on the column**

Slenderness ratio **λ=** $\frac{0.7h}{a}$**,** where λ= slenderness ratio; h= effective height ; a= width of column

As= $\frac{\frac{N}{\varphi}}{Rsc}$**- R_b × A_b,** where As= total cross section of steel reinforcement; N: total load on the floor; R_b= design concrete compressive strength, A_b= area of column cross section; R_{sc}= area of steel compressive strength; φ= coefficient used to take into account the column slenderness and the construction inaccuracies (Mac-Ginley and Choo, 1990)

3.6.1.4. Design of foundation

A foundation is the lowest portion of a structure that bears loads from higher parts of the structure and distributes those loads evenly (to the same extent or to prevent the building from failing) (uneven settling of building).

I. Spacing of bars

Spacing= $\frac{b-2cover-n\times main\ bar}{n-1}$, where b= width of foundation and n= number of steel bar.

II. Eccentrically loaded paid foundation

E= $\frac{M+h}{P+W}$**,** where e= eccentrically; M+h= moment on the column and P+W= load on the foundation.

Condition**:** $\frac{L}{6} < e$, where L= size of foundation

P_{max}= $\frac{P+W}{A}+\frac{M+h}{Z} > bearing\ capacity$, where A= area and Z= sectional modulus= $\frac{bl2}{6}$

Condition: $P_{max} \geq$ bearing capacity

$$\mathbf{P_{mix}} = \frac{P+W}{A} - \frac{M+h}{} \leq 0 KN/m^2$$

a) **Load foundation**

Total load permanent load= design load – total live load

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

Total characteristic permanent load= $\frac{tatal\ dead\ load}{safety\ factor\ of\ dead\ load}$

Total characteristic load= total characteristic permanent load + total characteristic live load

Estimate weight of soil on foundation= 10% to total characteristics

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

b) **The required area of foundation**

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

Where A_f : area of foundation

3.6.1.5. Design pressure

$\mathbf{P} = \frac{NC}{Af}$, where P: design pressure; NC: load on the column

I. Checking of shear force

The shear forces $\mathbf{Q \leq 0.54 \times R_{bt} \times A_b}$

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

$\mathbf{A_b = Af \times ho}$; where Af: width of the foundation, ho: effective height of slab

$Q = P \times b_f (l_c - h_o)$, where P: design pressure, bf: length of foundation, l_c: distance between from the effective height to the end of the foundation, ho: effective height .

$L_c = \frac{bf}{2} - \frac{bc}{2}$, where bf: length of the foundation, bc: width of the column

II. Checking for punching shear

$Q_f = N_f - V_q \leq R_{bt} \times AB$, where Q_f: punching shear force, N_f: load transmitted y the column to the foundation, V_q: balancing shear force

AB= Um ×ho, where Um: average perimeter

Um= 2 (ac + bc + 2ho) where ac: width of column, bc: length of the column

$V_q = P\,(ac + 2ho)^2$

III. Moment calculation

$M_{max} = \left(\frac{Paf}{2}\right)\left(\frac{bf-bc}{2}\right)^2$, where M_{max}: maximum moment, P: design pressure, af: width of foundation, bf: length of the foundation, b_c: length of column.

As= $\frac{M}{0.9 \times ho \times Rs}$, where M: maximum moment, ho: effective height of the foundation, Rs: design steel tensile stress.

3.6.1.6 Design of stair

A stair is structural element that allows the movement from one floor to another floor.

$\Theta = \tan^{-1}$ $\frac{H}{G}$ where H: rise and G: going

he= $\frac{H}{2} + \frac{dl}{cosa}$ where he : effective height, dl: waist, H: going (Mosley et al, 2007)

I. Dead load

Dead load= safety factor × equivalent thickness × meter × unit weight

Finishes= safety factor × thickness of finishes

II. Live load

Live load= safety factor × live load of material

III. Required steel reinforcement in the stair

am= $\frac{M}{Rb \times ho \times ho \times b}$ where am: coefficient 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 is positive the moment is at the bottom; but if is negative the moment is t the top.

As= $\frac{M}{\eta \times Rs \times ho}$ where As: total cross section of steel, Rs: design steel tensile stress, ho: effective height, η: coefficient related to the design of member subjected to bending moment.

3.7 Topography

3.7.1 Leveling

You determine the height dimension in relation to a fixed point, or datum, throughout this levelling process. A treasure level called a "date" differs between nations. The first thing is to succeed in what I'm doing, as stated in the ground where I placed my building. Making a map of my plot was my goal as I was levelling. If the scale is small, the presentation is known as a map. The reason it differs from the plan is that you state "plan" if the scale is big.

To level my plot and accomplish my goal of creating a map of my suggested plot, I employ a variety of tools and equipment. These tools and equipment include pegs, a tape measure, and an automated.

3.8 Setting out and installation

Setting out is the process of measuring and taking dimensions from the plan and attempting to depict or translate those dimensions onto the ground. Prior to taking any action or doing any activity, I must meet the following requirements:

To comprehend the following:

a) the setting out's goal; b) the site's features; and c) the roles of the many participants in the setting out process.

When I was in the setting, I would have to assemble the necessary tools, like the following: a) Working Drawings; b) Hammers; c) Nails; d) Buildings; e) Squares; f) Tape Measures; g) And So On.

For working a right angle for a rectangular or square you can use the different method such as: Use builders, square, and traditional method 3-4-5 triangle for myself I have to use 3-4-5 for checking the right angle This method is very used for different building and it is very trusted for avoiding A loop was tied on each end of the piece of string before it was precisely measured to be cut at 5600mm.

Affix the two loop strings to the first peg using nails.

a) Extend the string and position a peg 900mm away from the first peg.

b) Pass the string around and position the third peg 1200 mm from the first peg. some errors the process followed while the 3-4-5 triangle.

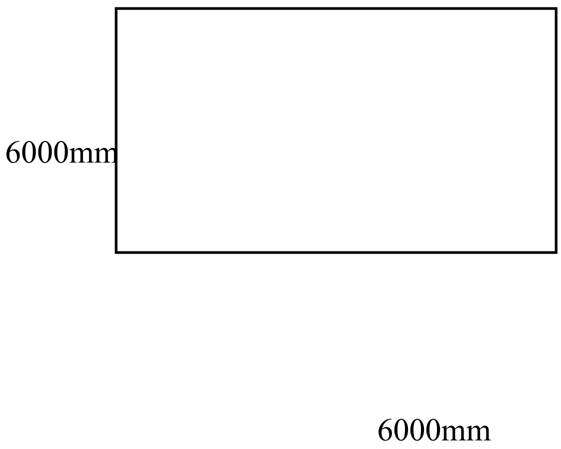
CHAPTER 4. DESIGN SPECIFICATION (RESULT AND DISCUSSION)

4.0. Introduction

This chapter highlights the result and discussion, it shows the presentation of the result acquired after calculation.

4.1. Calculations

4.1.1. Design of slab



If $\frac{ly}{lx} \leq 2$, the slab is a two way slab

If $\frac{ly}{lx} > 2$, the slab is a one way slab

Ly/lx= $\frac{6000}{6000}$ = 1 < 2, the slab is a two way slab

Thickness of slab

The thickness of slab is ranging between $\frac{lx}{20}$ and $\frac{lx}{40}$.

$\frac{lx}{20} = \frac{6000}{20} = 300$mm

$\frac{lx}{40} = \frac{6000}{40} = 150$mm

Assume thickness= 300mm

Calculation of loads

1) Dead load calculation

Self-weight of slab= thickness of slab × 1.4 × unit weight of concrete × breadth f slab (b=1m)

Self-weight= 25 × 1.4 × 0.3 × 1= 10.5KN/m^2

Finishes= Self-weight of finishes × 1.4 × breadth of slab= 1.4 × 19 × 1= 26.6KN/m^2

Total dead load= 10.5 + 26.6= 37.1KN/m^2

2) Imposed load calculation

Imposed load= 1.6 × imposed load from table BS 6399:1-1996= 1.6 × 3 = 4.8 KN/m^2

3) Design load= dead load + imposed load = 37.1 + 4.8 = 41.9KN/m ie = 42KN/m^2

Calculation of moment

$Ms_x^-= Bs_x \times n \times (lx)^2$ where Bs_x= 0.031

$Ms_x^-= 0.031 \times 42 \times (6)^2 = 46.9$ KN

$Ms_y^-= Bs_y \times n \times (ly)^2$ where Bs_y= 0.024

$Ms_y^-= 0.024 \times 42 \times (6)^2 = 36.3$KN/m

$Ms_x= Bs_x \times n \times (lx)^2$where Bsx= 0.032

Msx= 0.032 × 42 × $(6)^2$= 48.4KN/m

$Ms_y= Bs_y \times n \times (ly)^2$ where Bsy= 0.024

Msy= 0.024 × 42 × $(6)^2$= 36.3KN/m

Shear force calculation

$Vs_{x=}\ Bv_x \times n \times lx$, where Bv_x= 0.33

Vs_x= 0.33 × 42× 6= 83.2KN

$Vs_y = Bv_y \times n \times ly$, where $Bv_y = 0.33$

$Vs_y = 0.33 \times 42 \times 6 = 83.2KN$

- Moment at $Ms_x = 48.4KNm = M$

$MRC = 0.156fcubd^2$

$d = h - cover - \frac{main\ bars}{2} = 300 - 25 - \frac{16}{2} = 267mm$

$MRC = 0.156 \times 30 \times 1000 \times (267)^2 = 333632520Nmm = 333.6KNm$

MRC > M, no compression

$K = \frac{M}{fcubdsq} = \frac{48400000}{21386700000} = 0.022$

K< Kbal, no compression

$$Z = d\left[0.5 + \sqrt{0.25 - \frac{K}{0.9}}\right] = 267\left[0.5 + \sqrt{0.25 - \frac{0.022}{0.9}}\right]$$

Z= 258.9mm

Z> 0.95d= 0.95 × 267= 253.6mm, let's take Z== 258.6mm

$Asreq = \frac{M}{0.95fyz} = \frac{48400000}{110823.2} = 436.7mm^2$

$Asprov = 452mm^2$ 4T12

- Shear force at $vs_x = 83.2KN$

$W = \frac{V}{bd} = \frac{83200}{267000} = 0.3N/mm^2$

$(\frac{100Asprov}{bd})^{1/3} = (\frac{100 \times 452}{267000})^{1/3} = 0.55 < 3$ OK

$(\frac{400}{d})^{1/4} = (\frac{400}{267})^{1/4} = 1.1 > 1$ OK

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

$Wc= \frac{0.79(100Asprov/bd)1/3(400/d)1/4(fcu/25)1/3}{1.25} = \frac{0.79\times0.55\times1.1\times1}{1.25} = 0.38N/mm^2$

W< Wc, no shear force reinforcement required

Deflection check

$MF= 0.55 + \frac{477-fs}{120(0.9+\frac{M}{bdsq})}$

$Fs= \frac{2}{3} \times fy \times \frac{Asreq}{Asprov} \times \frac{1}{Bd}$

$Fs= 295.9N/mm^2$

$\frac{M}{bdsq} = \frac{48400000}{71289000} = 0.68$

$MF= 0.55 + \frac{477-295.9}{120\times(0.9+0.68)} = 1.5<2$ OK

4.1.2 **Design of beam**

Lmax= 600mm= 6m

$Mmax=\frac{wlmax}{8} = 189KNm$

Thickness of beam= $\frac{lmax}{12} \leq h \leq \frac{lmax}{8}, \frac{6000}{12} \leq h \leq \frac{6000}{8}$

Assume h= 750mm

$d= h - cover - \frac{main\ bars}{2} = 750 - 25 - \frac{16}{2} = 717mm$

$MRC= 0.156fcubd^2 = 0.156 \times 30 \times 1000 \times (717)^2 = 2405936520Nmm = 2405.9KNm$

Mmax < MRC, no compression

$K= \frac{Mmax}{fcubdsq} = \frac{2405900000}{30\times1000\times514089} = 0.155$

K< Kbal, no compression

Z= d $\left[0.5 + \sqrt{0.25 - \frac{K}{0.9}}\right]$= 414.4mm

Z> 0.95d= 681.1mm

Assume Z= 414.4mm

Asreq= $\frac{Mmax}{0.95fyz}$= $\frac{2405900000}{0.95 \times 460 \times 414.4}$ = 1328.5mm^2

Asprv= 1407mm^2 7T16

Deflection check

MF= o.55+ $\frac{477-Fs}{120(0.9+\frac{Mmax}{bdsq})}$

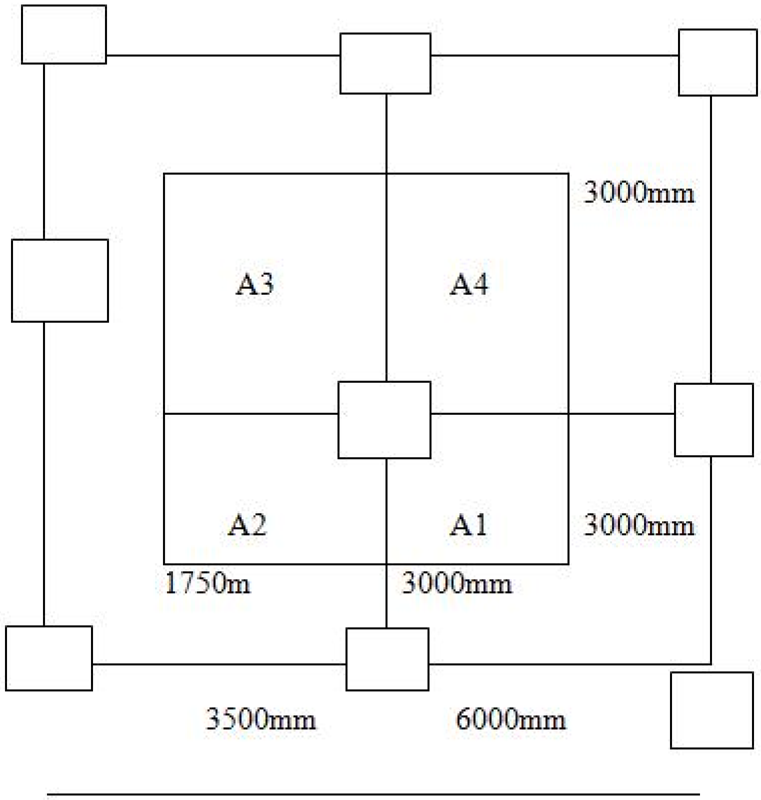
Fs= $\frac{2}{3} \times \frac{Asreq}{Asprv} \times \frac{1}{Bb}$

$\frac{Mmax}{bdsq}$= 0.36

Fs= 294.5N/mm^2

MF= 1.75< 2 ok

4.1.3 **Design of column**



Given data

Size of column = 40cm × 40cm

Thickness of column = 45cm

Design loads of slab = 42KN/m^2

Unit-weight of concrete = 25KN/m^3

Unit-weight of finishes = 19KN/m^3

Unit-weight of masonry = 22KN/m^3

Height of column = 3.5m

Breadth of column = 18cm

Breadth of beam = 25cm

Width of wall = 20cm

Thickness of finishes = 3cm

Live load from table BS 6399 = 3KN/m^2

A1= 3×3=9m^2

A2= 3×1.75= 5.25m^2

A3= 3×1.75=5.25m^2

A4= 3×3=9m^2

Influence area= A1+A2+A3+A4= 9+5.25+5.25+9=28.5m^2

Beam length= $[(3+3)+(1.75+3)-0.4]$= 10.35m

Wall length= $[(3+3)-0.4+(1.75+3)-0.4]$= 9.95m

Wall height= height of column-height f beam= 3.5-0.45=3.05m

Height of wall finishes= height of column-thickness of slab, where h of slab=300mm=0.3m

Height of wall finishes= 3.5-0.3= 3.2m

Calculation of loads

1) **Dead loads**

Self-weight of column= 1.4 × width of column × breadth of column × height column × unit-weight of concrete= 1.4 × 0.4 ×0.4× 3.5 × 25= 19.6KN

Load from slab= design of loads of slab per unit area × influence area = 42 × 28.5= 119.7KN

Load from beam= 1.4 × breadth of beam × thickness of beam × beam length × unit-weight of concrete = 1.4 × 0.25 × 0.45 × 10.35 × 25 = 40,7KN

Load from masonry= 1.4 × width of wall × height of wall × wall length × unit-weight of masonry= 1.4 × 0.2 × 3.05 × 9.95 × 22= 186.9KN

Load from finishes= 1.4 × thickness of finishes × height of wall × wall length × 2 × unit-weight of finishes= 1.4 × 0.03 × 3.05 × 9.95 × 2 × 19= 48.4KN

2) Live load

Live load= 1.6 × live load from table BS6399 × influence area = 1.6 ×3 × 28.5= 136.8KN

Load on column ground floor

N1= (load from slab+ load from beam+ load from wall masonry+ load from finishes+ live load) × 7 + (self-weight of column) × 8 + (load from beam+ load from slab+ live load)=(119.7+40.7+186.9+48.4+136.8) × 7 + (19.7) × 8 + (40.7+110.7+136.8)=4,181.5KN

N2= (load from slab+ load from beam+ load from wall masonry+ load from finishes+ live load) × 6 + (self-weight of column) × 7 + (load from beam+ load from slab+ live load)=(119.7+40.7+186.9+48.4+136.8) × 6 + (19.7) × 7 + (40.7+110.7+136.8)=3,629.4KN

N3= (load from slab+ load from beam+ load from wall masonry+ load from finishes+ live load) × 5 + (self-weight of column) × 6 + (load from beam+ load from slab+ live load)=(119.7+40.7+186.9+48.4+136.8) × 5 + (19.7) × 6 + (40.7+110.7+136.8)=3,077.3KN

N4= (load from slab+ load from beam+ load from wall masonry+ load from finishes+ live load) × 4 + (self-weight of column) × 5 + (load from beam+ load from slab+ live load)=(119.7+40.7+186.9+48.4+136.8) × 4 + (19.7) × 5+ (40.7+110.7+136.8)=2,525.2KN

N5= (load from slab+ load from beam+ load from wall masonry+ load from finishes+ live load) × 3 + (self-weight of column) × 4 + (load from beam+ load from slab+ live load)=(119.7+40.7+186.9+48.4+136.8) × 3 + (19.7) × 4 + (40.7+110.7+136.8)= 1,973.1KN

N6= (load from slab+ load from beam+ load from wall masonry+ load from finishes+ live load) × 2 + (self-weight of column) × 3 + (load from beam+ load from slab+ live load)=(119.7+40.7+186.9+48.4+136.8) × 2 + (19.7) × 3 + (40.7+110.7+136.8)=1,421KN

N7= (load from slab+ load from beam+ load from wall masonry+ load from finishes+ live load) × 1+ (self-weight of column) × 2 + (load from beam+ load from slab+ live load)=(119.7+40.7+186.9+48.4+136.8) × 1 + (19.7) × 2 + (40.7+110.7+136.8)=868.9KN

N8= (load from slab+ load from beam+ load from wall masonry+ load from finishes+ live load) × 0 + (self-weight of column) × 1 + (load from beam+ load from slab+ live load)=(119.7+40.7+186.9+48.4+136.8) × 0 + (19.7) × 1 + (40.7+110.7+136.8)=316.8KN

KBA= $\frac{1}{2} \times \frac{bhmeter\ cube}{12LBA} = \frac{1}{2} \times \frac{0.25 \times 0,091125}{12 \times 6}$ = 1.6 × 10^{-4} = 0.00016

KBC= $\frac{1}{2} \times \frac{bhmeter\ cube}{12LBC}$ = 0.00016

KBD= Kcol= $\frac{bhmeter\ cube}{12LBD} = \frac{0,4 \times 0.064}{12 \times 3.5}$ = 6.09 × 10^{-4}= 0.000609

∑K = KBA + KBC + Kcol= 0.00016+0.00016+0.000609= 0.000929

Distribution factor= $\frac{Kcol}{\sum K}$ = 0.655

Fixed end moment at point B

FEMBA= $\frac{qlsq}{12}$= 178.9KN

FEMBC= $\frac{qlsq}{12}$= 111.3KN

Difference of moment= FEMBA-FEMBC= 67.6KN

Design moment= difference of moment × distribution factor= 44.3KNm

My= 44.3KNm

KBA= $\frac{1}{2} \times \frac{0.25 \times 0,091125}{12 \times 3.5}$ = 0.00027

KBC= $\frac{1}{2} \times \frac{0.25 \times 0.091125}{12 \times 6}$=0.00016

Kcol= $\frac{0.4 \times 0.064}{12 \times 3.5}$= 0.000609

$\sum K= 0.0035$

Distribution factor= 0.174

Fixed end moment at point B

FEMBA= 60.9KN

FEMBC= 111.3KN

Difference of moment= 50,4KNm

Design moment = 8.8KNm

Mx= 8.8KNm

h'= h-cover-$\frac{main\ bar}{2}$- links , where h=thickness of beam= 750mm and links= 8mm

h'= 750-25-8-8=709mm

b'= 709mm

N/bhfcu	0	0.1	0.2	0.3	0.4	0.5	0.6
B	1.00	0.88	0.77	0.65	0.53	0.42	0.30

Table 4 1 Values of the coefficient β

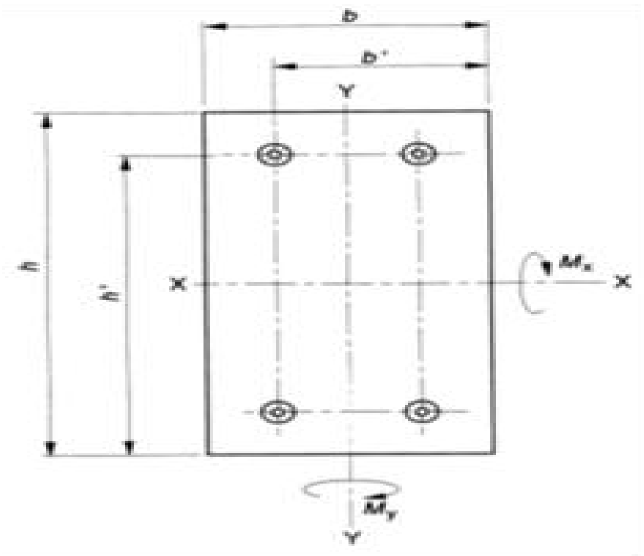


Figure 4 1 Condition of moment

Condition

If $\frac{Mx}{h'} > \frac{My}{b'}$; the increase moment Mx'= Mx+ $\beta\frac{h'}{b'}$My

If $\frac{Mx}{h'} < \frac{My}{b'}$; the increase moment My'= My + $\beta\frac{b'}{h'}$Mx

$\frac{Mx}{h'} = \frac{8.8}{709} = 0.0124$

$\frac{My}{b'} = \frac{44.3}{709} = 0.0624$

$\frac{N}{bhfcu} = \frac{4181500}{709 \times 709 \times 30} = 0.3$

β= 0.65

$\frac{Mx}{h'} < \frac{My}{b'}$; the increase moment My'= 44.3 + 0.65 × $\frac{709}{709} \times 8.8 = 50.02KNm$

4.1.4 Design of footing

Characteristic load= 1.0GK+1.0QK

Where, Dead load= 415.3KN/m^2

Live load= 136.8KN/m^2

Characteristic load= 552.1KN/m^2

Load of footing= 1.4 GK + 1.0 QK= characteristic load of column +W

W= 10% (1.4GK+1.0QK) = 71.822KN

Load of footing= 552.1+ 71.822= 623.9KN

Area of footing= $\frac{load\ of\ footing}{bearing\ capacity} = \frac{623.9}{250} = 2.5m^2$

Area of footing= $\sqrt{2.5}$=1.6m^2

Size of footing= 1.6m×1.6m

Rectangular footing, let's assume one side 2.5m and other side $\frac{2.5}{1.6}$ = 1m

2.5m×1m

Condition

If design stress $> bearing\ capacity, the\ footing\ is\ unsafe$

If design stress $< bearing\ capacity, the\ footing\ is\ safe$

Design stress=$\frac{design\ load(Nd)}{Area\ of\ footing} = \frac{552.1}{1.6\times1.6} = 215.7KN/m^2$

Design stress < bearing capacity, the footing is safe.

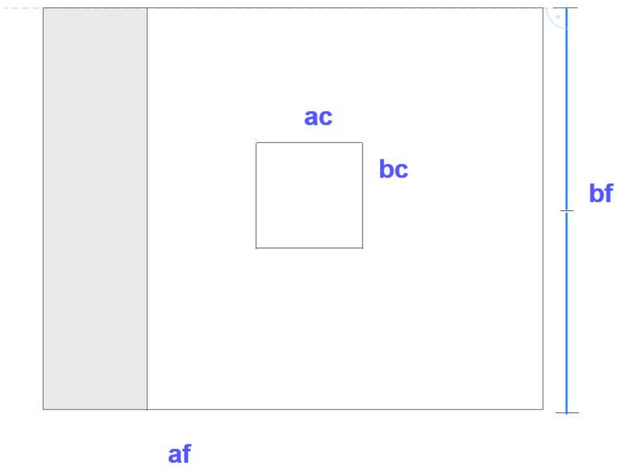


Figure 4 2 check for vertical shear

P= pressure/design stress= 215.7KN/m^2= 0.02157KN/cm^2

af= 1600mm

bf= 1600mm

ac= 40cm

bc= 40cm

Rb= 0.09

t= thickness-cover-$\frac{main\ bar}{2}$= 50-25-8=17cm

Q≤ $0.54 \times Rb \times af \times t = 132.2KN$

Q= P × bf × S= 134.8KN

4.1.5 Design of stair

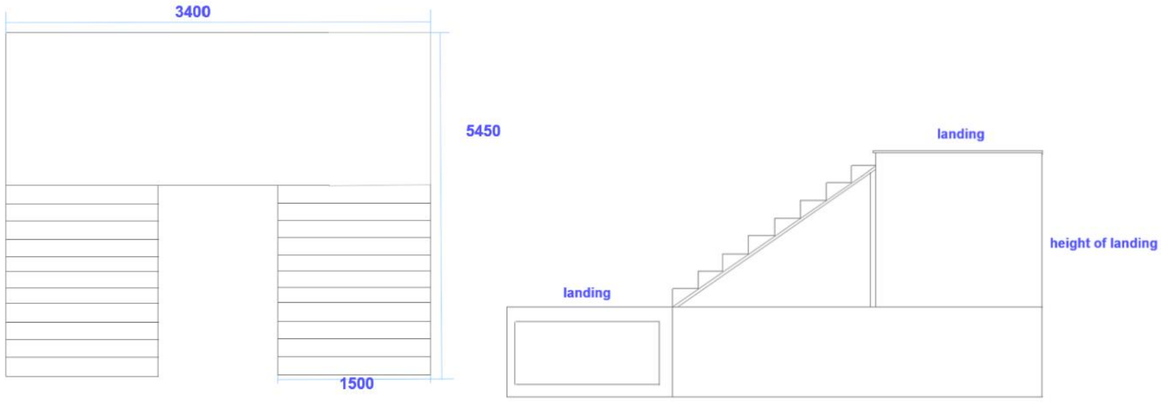


Figure.4. 2.stair

Height of landing= 1.75m= riser of flight

Height of column= 3.5m

Breadth of beam= 25cm

Number of going= 10

Number of riser=10+1=11

Size of riser= $\frac{1750}{11} = 160mm$

2R+G= $\frac{700+550}{2} = 625mm$

G= 625-2R= 625-2×160=305mm

Effective horizontal length= La+ 0.5(Lb1+Lb2)= 3.4+0.5(0.25+0.25)= 3650mm

Length of going of flight= number of going × size of going = 10 × 305= 3050mm

Centre to centre length of flight=3050+0.5(250+250)= 3300mm

Length of flight= $\sqrt{(riser\ of\ flight)sq + (\ lenght\ of\ flight)sq}$=$\sqrt{13952500}$=3.7353m

Slope= $\tan^{-1}\alpha = \frac{riser\ of\ flight}{horizontal\ lenght\ distance}$

Tan^{-1}= 0.53

α= 27.9^0

Depth of waist= $\frac{effective\ \text{horizontal distance}}{26} = \frac{3650}{26} = 140\text{mm}$

Thickness= effective depth + $\frac{\text{main bar}}{2}$ +over = 140+25+8= 175mm

Dead load calculation

Out of landing

Self-weight=1.4×thickness of stair × length of flight × width of flight × unit-weight of concrete

$\text{Sin}\alpha = \frac{\text{ac}}{305\text{mm}} = 142.7\text{mm}$

Thickness of stair including finishes=thickness of waist + $\frac{\text{calculated thickness of step}}{2}$ + thickness of finishes= 249.35mm

Self-weight= 1.4× 0.24935× 3.7353 ×1.5×25=48.9KN

Imposed load= 1.6× length of flight× width of flight× imposed load from table 1 of 6399:1-1997= 1.6× 3.7353× 1.5× 3= 26.9KN

Total design on stair slab = 75.8KN

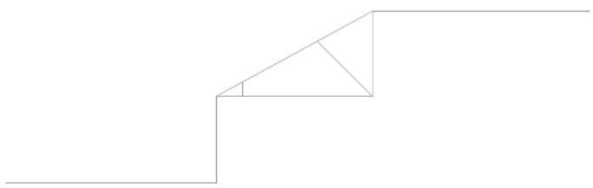


Figure 4 3 Out going of landing

Landing

Self-weight of landing= (1.4× width of landing× thickness of landing× unit-weight of concrete) × 0.5= 4.6KN

Imposed load= (1.6× width of landing× impose load BS6399:1-1997) × 0.5= 1.26KN

Total design load= 5.86KN

Total load on span length= 81.66KN

Mmax=$\frac{WL}{10} = 30\text{KNm}$

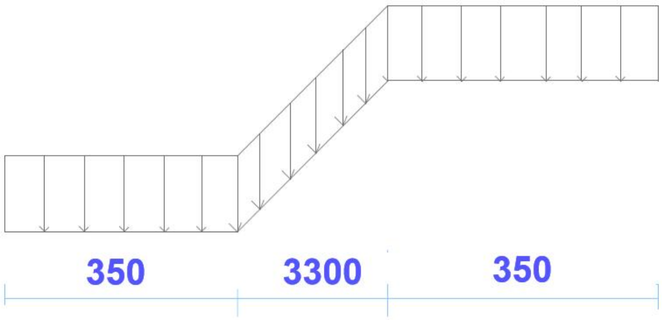


Figure 4 4 Design load of stair

Figure 4 5 Shear force of stair

∑M=0, 5.586× 0.175+ 75.8× (0.175+0.175+1.65)-RB × (0.35+3.3)

RB= 41.8KN

RA+RB=81.66KN

RA=39.86KN

Shear force at D= 35.94KN

Shear force at C= - 41.8KN

Shear force at A= - 41.8KN

4.2 Cost estimating

Bill of quantity and cost estimation substructure

SN	Description	Un it	Quantit y	Rate (Rwf)	Total amount (Rwf)
	PRELIMINARY WORKS (provisional)				
	Site clearing	m^2	9000m^2		18.000.000
	Enclosure, shack and office	LS	1		3.000.500
	SUBSTRUCTURE				
	EARTHWORKS (Provisional)				
	Excavation and site leveling				
	Excavation works and site leveling prior to setting out and foundation works to include hauling of excavated soil from construction site.	LS	1		8.600.000
	Excavation works for foundation to include maintaining and supporting trenches sides and keeping them free from water, mud and fallen materials				
	For column bases (footings)	m3	76.8	50.000	3.840.000
	FONDATION WORKS (Provisional)				
	Vibrated reinforced concrete for:				
	column bases (footings)	m3	76.8	450.000	34.560.000
	SUB-TOTAL: SUBSTRUCTURE				**68.000.500**
	SUPERSTRUCTURE				
	GROUND FLOOR				

	REINFORCED CONCRETE WORKS				
	Vibrated reinforced concrete for:				
	Columns	m^3	67.2	450.000	30.240.000
	Floor beams	m^3	247.5	450.000	111.375.000
	Slab	m^3	404.8	450.000	182.160.000
	Masonry wall				
	Blocks	Nr	20.460	860	17.595.600
	Mortar	m^3	163.68	200.000	32.736.000
	SUB-TOTAL: SUPERSTRUCTURE				**505.251.000**
	WALL FINISHES				
	WALL PLASTERING & PAINTING				
	Wall plastering External and Internal walls	m^2	1705	15.000	25.575.000
	Painting external and internal Walls	m^2	1705	45.000	76.725.000
	Prepare and application of lime plaster to:				
	External and Internal walls	m^2	1705	5.000	8.525.000
	SUB-TOTAL: WALL FINISHES				341.007.000
	FLOORING				
	FLOORING				
	Floor tiling with corresponding Tiles	m^2	2024	80.000	161.920.000
	SUB-TOTAL: FLOORING and WALL FINISHES				**502.927.000**

	WINDOWS				
	Supply and fixation of glazed window with aluminum frames to include locking devices and accessories, painting and all Requirements				
	Double-hung window 1500mm x 1500mm	Nr	34	130.000	4.420.000
	Double-hung window 100 mm x 100 Mm	Nr.	32	70.000	2.240.000
	SUB-TOTAL: WINDOWS				**6.660.000**
	DOORS				
	Double entrance door door 2500 mm x 2500 mm	Nr	1	220.000	220.000
	Wooden door 2100 mm x 900 Mm	Nr.	68	130.000	12.080.000
	SUB-TOTAL: DOORS				**12.210.000**
	SANITARY APPLIANCES				
	Supply and installation of WC with all accessories and all requirement	Nr.	32	220.000	7.040.000
	Supply and installation ion of ceramic wash hands basin complete	Nr	3	150.000	450.000
	with accessories and all requirements.				
	SUB-TOTAL: SANITARY APPLIANCES				**7.490.000**
	SUB-TOTAL:GROUND FLOOR				**1.034.538.000**
	TOTAL: GROUND FLOOR AND SUBSTRUCTURE				**1.034.538.000**

Summary of cost and estimation of the building

SN	ITEM	AMOUNT(RWF)
1	Foundation and ground floor	1.034.538.000
2	First floor	1.034.538.000
3	Second floor	1.034.538.000
4	Third floor	1.034.538.000
5	Fouth floor	1.049.076.000
6	Fifth floor	1.049.076.000
7	Sixth floor	1.049.076.000
8	Seventh floor	1.049.076.000
	GRAND TOTAL	8.334.456.000

Additional Notes:

•All cost figures are provided in Rwf.

•The estimated costs are based on the information available at the time of estimation and may be subject to change.

CHAPTER 5. CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter highlights it about the conclusion and recommendation with respect to the predefined objectives.

5.1 Conclusions

The goal of this project work is to design the modern stadium's reinforced concrete structural elements using the master plan as a guide.

Regarding academic interest, working on this project has helped the students become more proficient in structural software and has significantly enhanced their ability to design structures. Additionally, this project gives us a strong foundation in the design of reinforced concrete structures, which will help us enter the market.

I gained a great deal of knowledge about structural design and came to the conclusion that, because reinforced concrete weighs more than other structures, its structural design requires more consideration than other structures. Nevertheless, risk should be taken if reinforced concrete is not suitable for the building or the soil foundation.

5.2 Recommendation

To any students who's inspired by the work done in this project its recommended to give their contribution on the project and work on the design of the remaining items such as, electrical plumbing installations, rainwater.

For anyone planning to design a similar building, it's recommended to use different design software tools. This not only speeds up the process but also helps reduce mistakes that might happen when designing by hand.

REFERENCES

- ✓ https://www.activesustainaility.com≥sustainable-building
- ✓ https://www.rha.gov.rw./2/public-building
- ✓ https://en.wikipedia.org/wiki/hotel//hotel room//redirect here. for the 1993 HBO television series, see hotel room
- ✓ The editors of encyclopedia Britannica Apr 19, 2024. Article History
- ✓ The hotel business of Rwanda
- ✓ Apartment evolution in Rwanda report
- ✓ © W.H. Mosley, R. Hulse and J.H. Bungey 1996
- ✓ Design of reinforcement cement concrete element
- ✓ aairatanga@gmail.com
- ✓ http://www.buildsoft.ev≥buildsoft≥Blog
- ✓ Structural use of concrete: Part 1: Code of practice for design and construction
- ✓ Imasiku, K., & Ntagwirumugara, E. (2019) An Impact Analysis of Population Growth on Energy-Water-Food-Land Nexus for Ecological Sustainable Development in Rwanda
- ✓ Neville, A. M., & Brooks, J. J. (2010) Concrete Technology
- ✓ Mindess, S., Young, J. F., & Darwin, D. (2003) Concrete Technology
- ✓ Hewlett, P. C. (2004) Lea's Chemistry of Cement and Concrete
- ✓ Taylor, H. F. W. (1997) Cement Chemistry
- ✓ Kosmatka, Kerkhoff, & Panarese (2002) Design and Control of Concrete Mixtures
- ✓ Mehta, P. K., & Monteiro, P. J. M. (2014)
- ✓ Neville, A.M.(2011)properties of concrete, 5th Edition
- ✓ Kosmatka, S.H.& Wilson, M.l.(2016) design and control of concrete mixture, 16th Edition
- ✓ Allen, E., & Iano, J.(2014). Fundamentals of Building Construction: Materials and Methods.
- ✓ Arya, C. (2022). Design of Structural Elements: Concrete, Steelwork, Masonry and Timber Designs to Eurocodes. London: CRC Press.
- ✓ Chen, W. F. (2007). Plasticity in reinforced concrete. . New-York: J. Ross Publishing.
- ✓ Ching, F., & Winkel, S. (2012). Building Co des Illustrated 4thed. Chicago: Wiley.
- ✓ Day, K. W. (2006). Concrete mix design, quality control and specification. London: CRC press. Dodson, V. (2013). Concrete admixtures. Mumbai: Springer Science & Business Media.
- ✓ Elwood, K., & Eberhard, M. (2009). Effective Stiffness of Reinforced Concrete Columns. ACI Structural Journal , 10 (4).

- Galambos, T., & Ravindra, M. (1981). Load and resistance factor design. Engineering Journal, AISC , 18 (3), 78-84.
- Gambhir, M. (2008). Design of reinforced concrete structures. Chicago: PHI Learning Pvt. Ltd.
- Imasiku, K., & Ntagwirumugara, E. (2019). An impact analysis of population growth
- on energy- water-food-land nexus for ecological sustainable development in Rwand. Food and Energy Security , 9 (1).
- Iyengar, K. (2015). Sustainable architectural design: An overview. New-York: Routledge.
- Smith, P. (2016). Structural design of buildings. New-York: John Wiley & Sons.
- Sreeshna, K. (2016). Analysis and Design of an Apartment building. IJISET– International Journal of Innovative Science, Engineering & Technology , 3 (3), 456-479.

APPENDIX

Table 5. 1. Bending moment coefficients for rectangular panels supported on four sides with provision for torsion at corners.

Type of panel and moments considered	Short span coefficients, βsx								Long span coefficients, βsy for all values of ly/lx
	Values of ly/lx								
	1.0	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.75**	**2.0**	
Interior panels									
Negative moment at continuous edge	0.031	0.037	0.042	0.046	0.050	0.53	0.59	0.63	0.32
Positive moment at mid-span	0.024	0.028	0.032	0.035	0.037	0.040	0.044	0.048	0.024
One short edge discontinuous									
Negative moment at continuous edge	0.039	0.044	0.048	0.052	0.055	0.058	0.063	0.067	0.037
Positive moment at mid-span	0.029	0.033	0.036	0.039	0.041	0.043	0.047	0.050	0.028
One long edge discontinuous									
Negative moment at continuous edge	0.039	0.049	0.056	0.062	0.068	0.073	0.082	0.089	0.037
Two adjacent edges discontinuous									

Negative moment at continuous edge	0.047	0.056	0.063	0.069	0.074	0.078	0.087	0.093	0.045
Positive moment at mid-span	0.036	0.042	0.047	0.051	0.055	0.059	0.065	0.070	0.034
Two short edges discontinuous									
Negative moment at continuous edge	0.046	0.050	0.054	0.057	0.060	0.062	0.067	0.070	—
Positive moment at mid-span	0.034	0.038	0.040	0.043	0.045	0.047	0.050	0.053	0.034
Two long edges discontinuous									
Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.045
Positive moment at mid-span	0.034	0.046	0.056	0.065	0.072	0.078	0.091	0.100	0.034
Three edges discontinuous (one long edge continuous)									
Negative moment at continuous edge	0.057	0.065	0.071	0.076	0.081	0.084	0.092	0.098	—
Positive moment at mid-span	0.043	0.048	0.053	0.057	0.060	0.063	0.069	0.074	0.044

Three edges discontinuous (one short edge continuous)									
Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.058
Positive moment at mid-span	0.042	0.054	0.063	0.071	0.078	0.084	0.096	0.105	0.044
Four edges discontinuous									
Positive moment at mid-span	0.055	0.065	0.074	0.081	0.087	0.092	0.103	0.111	0.056

Table 5. 2. Shear force coefficient for uniformly loaded rectangular panels supported on four sides with provision for torsion at corners

Type of panel and location	βvx for values of ly/lx								βvy
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	**2.0**	
Four edges continuous									
Continuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33
One short edge discontinuous									
Continuous edge	0.36	0.39	0.42	0.44	0.45	0.47	0.50	0.52	0.36
Discontinuous edge	—	—	—	—	—	—	—	—	0.24
One long edge discontinuous									
Continuous edge	0.36	0.40	0.44	0.47	0.49	0.51	0.55	0.59	0.36
Discontinuous edge	0.24	0.27	0.29	0.31	0.32	0.34	0.36	0.38	—

Two adjacent edges discontinuous									
Continuous edge	0.40	0.44	0.47	0.50	0.52	0.54	0.57	0.60	0.40
Discontinuous edge	0.26	0.29	0.31	0.33	0.34	0.35	0.38	0.40	0.26
Two short edges discontinuous									
Continuous edge	0.40	0.43	0.45	0.47	0.48	0.49	0.52	0.54	—
Discontinuous edge	—	—	—	—	—	—	—	—	0.26
Two long edges discontinuous									
Continuous edge	—	—	—	—	—	—	—	—	0.40
Discontinuous edge	0.26	0.30	0.33	0.36	0.38	0.40	0.44	0.47	—
Three edges discontinuous (one long edge discontinuous)									
Continuous edge	0.45	0.48	0.51	0.53	0.55	0.57	0.60	0.63	—
Discontinuous edge	0.30	0.32	0.34	0.35	0.36	0.37	0.39	0.41	0.29
Three edges discontinuous (one short edge discontinuous)									
Continuous edge	—	—	—	—	—	—	—	—	0.45
Discontinuous edge	0.29	0.33	0.36	0.38	0.40	0.42	0.45	0.48	0.30
Four edges discontinuous									
Discontinuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33

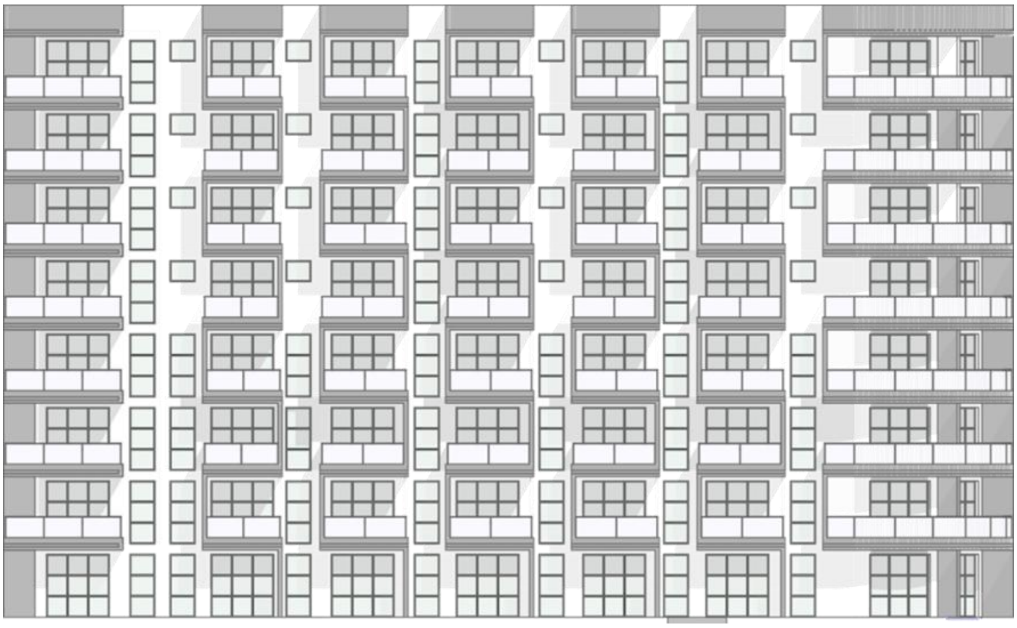
Table 5. 3.Area of bars in groups

Diameter(mm)	Number of bars in groups							
6	1	2	3	4	5	6	7	8
8	28	56	84	113	114	169	197	226
10	50	100	150	201	251	301	351	402
12	78	157	235	314	392	471	549	628
16	113	226	339	452	565	678	7791	904
20	201	402	603	804	1005	1206	1407	1608
25	314	628	942	1256	1570	1884	2199	2513
32	804	1608	2412	3216	4021	4825	5629	6433

PERSECTIVE VIEW

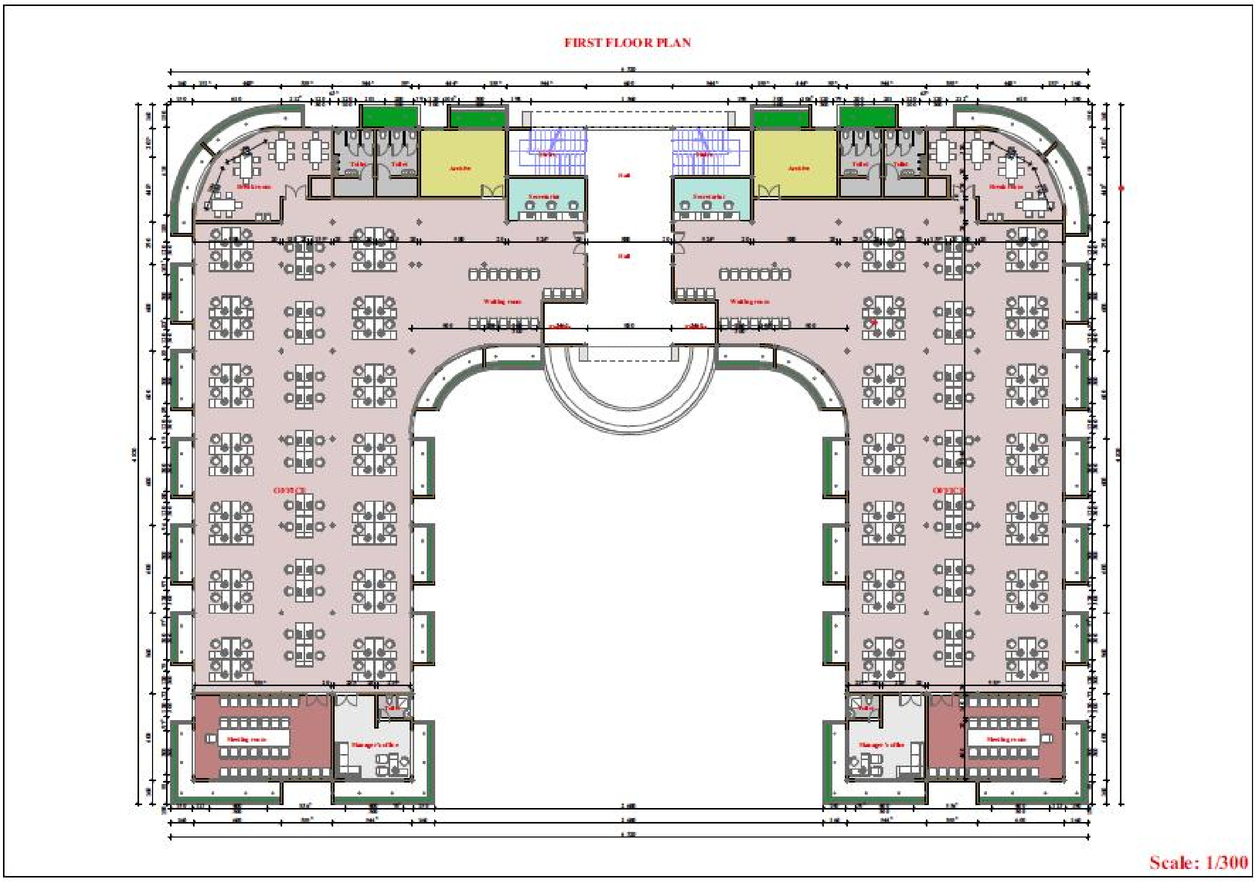
LEFT FAÇADE

RIGHT FAÇADE

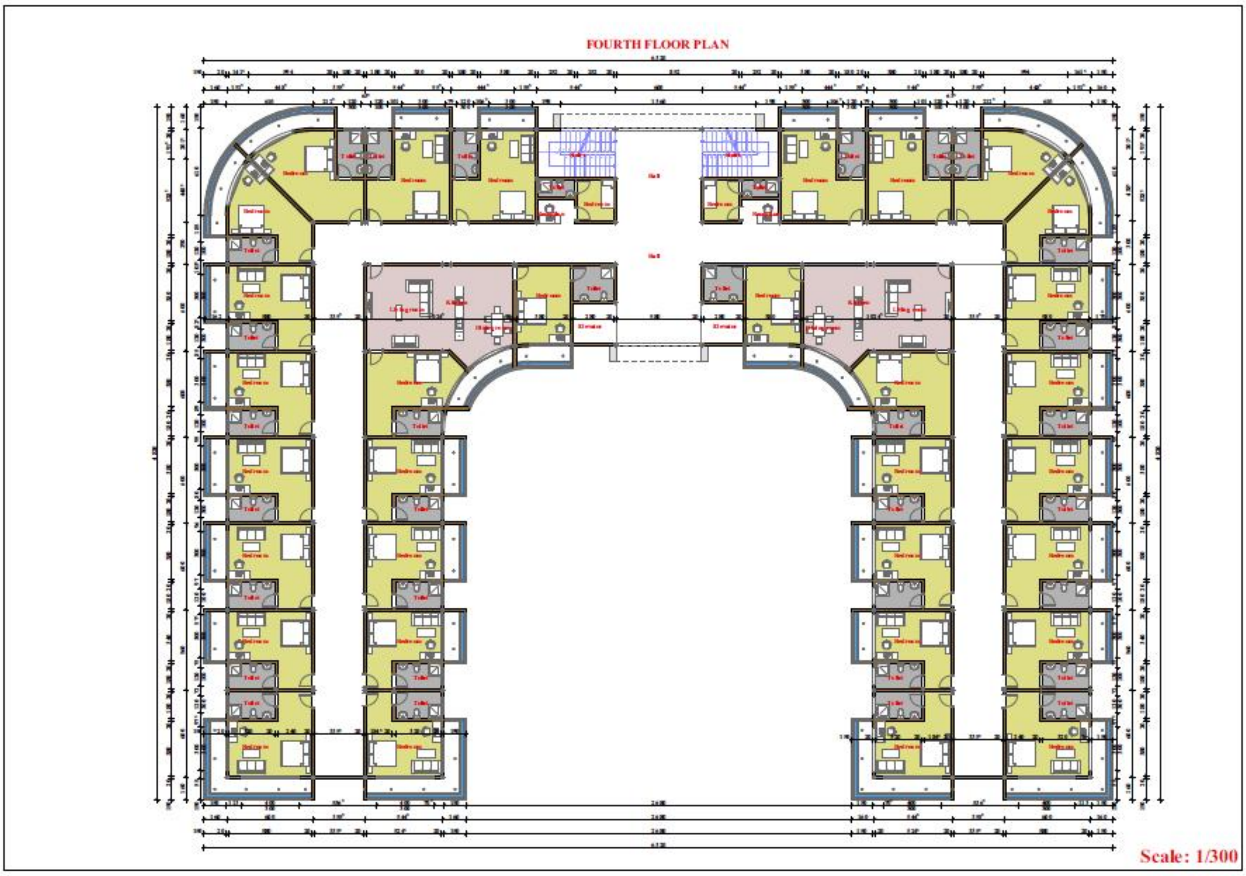


MAIN FAÇADE

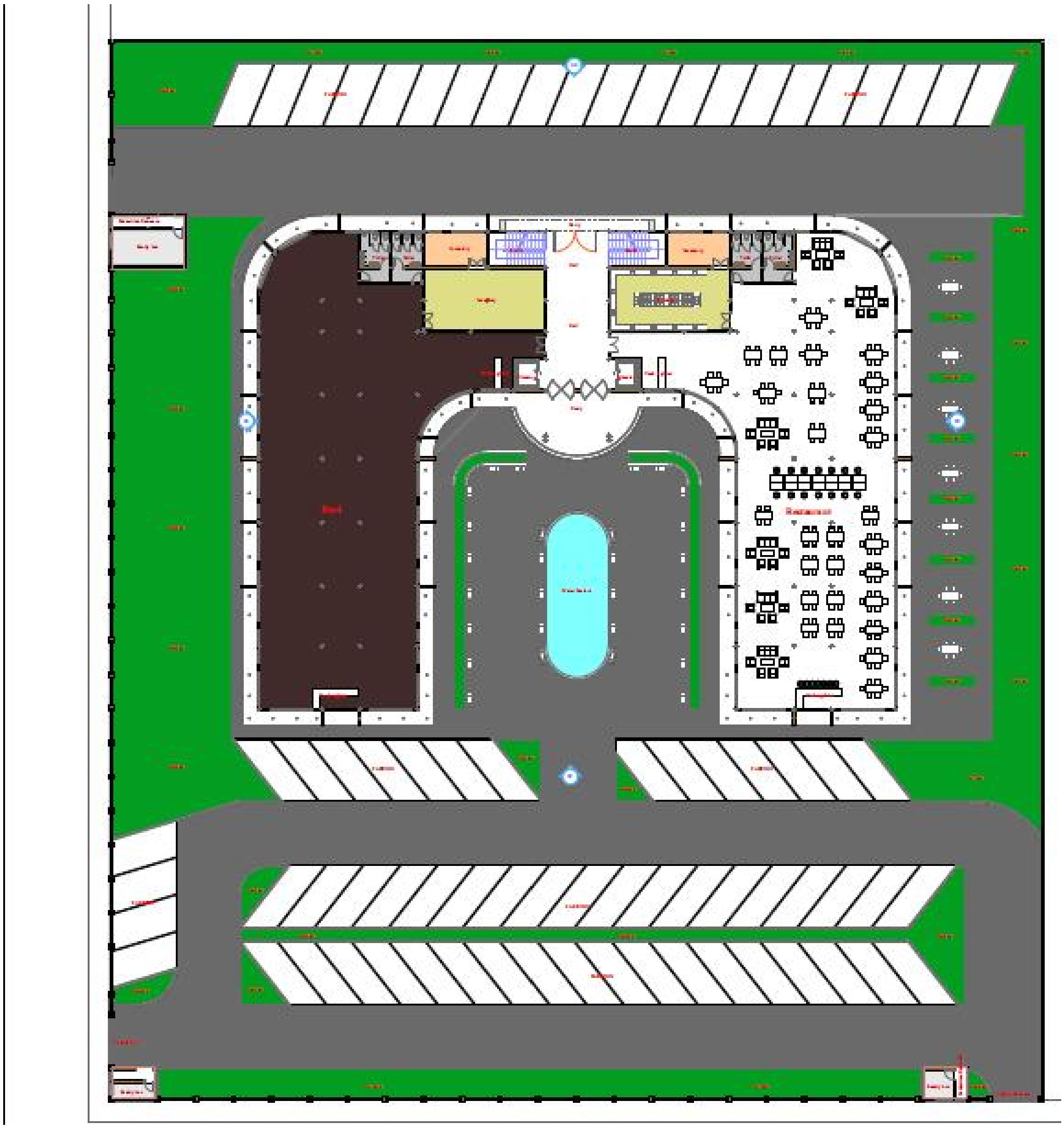
Ground floor until third floor is the same



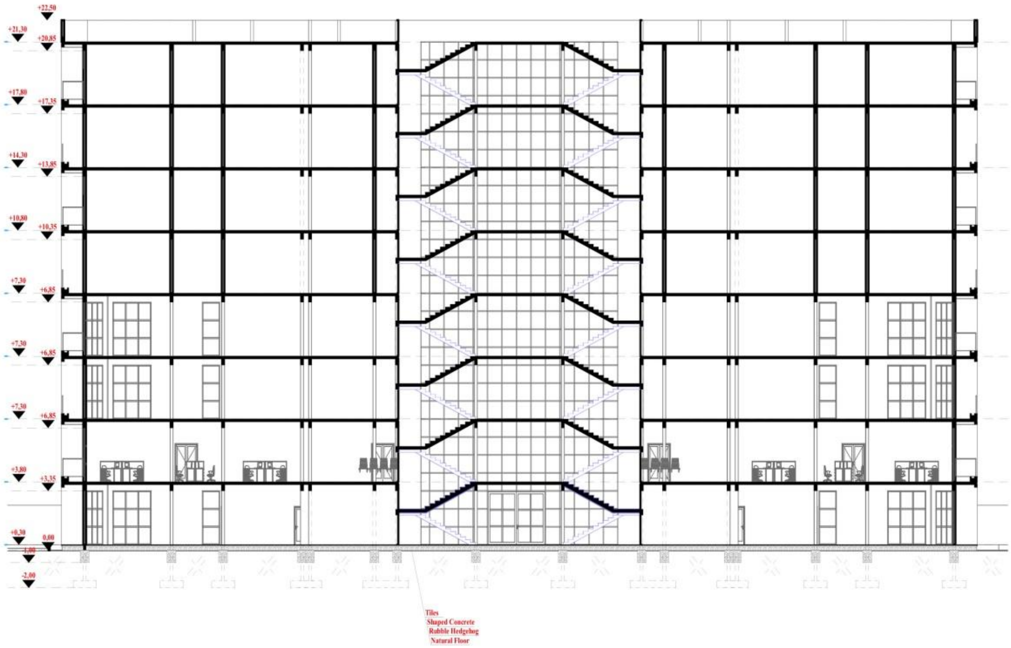
Fourth floor until seventh floor is the same



GROUND FLOOR ASSEMBLY PLAN VIEW



SECTION A-A



Scale: 1/300