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DEPARTMENT OF CIVIL ENGINEERING

OPTION: CONSTRUCTION TECHNOLOGY

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STRUCTURAL DESIGN OF MODERN MARKET WITH THREE STOREYS

CASE STUDY: NDERA SECTOR OF GASABO DISTRICT

Submitted to the Department of Civil Engineering in partial fulfillment of the requirements for the Award of **Advanced Diploma in Construction Technology**

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Kigali,September 2024

DECLARATION

I declare, MPAMBARA Antoine, that this research study is my original work to fulfil an Advanced Diploma in Civil Engineering (Construction Technology) and has not been presented for a degree or any other academic award in any university or institution of learning. No part of this research should be reproduced without the author's consent or that of ULK Polytechnic Institute.

MPAMBARA Antoine

Signature:…………………………

Date: ………./…………/2024

CERTIFICATE

This is to certify that this final project report, entitled "Architectural and Structural design of G+3 modern market building for Gasabo district, Ndera sector," submitted to ULK Polytechnic Institute, is the work of MPAMBARA Antoine. The project was carried out under my supervision, and to the best of my knowledge, it has not in any part been submitted to any other academic institution.

Supervisor Name	Head of Department
Eng.Bonaventure NKIRANUYE	Eng.Bonaventure NKIRANUYE
Date:………./…………../2024	Date :………./…………/2024
Signature : ……………………	Signature…………………….

DEDICATION

We dedicate this Final Project :

- To Almighty God;
- To my Parents;
- To my families;
- To my supervisor;
- To my Friends;
- To all who helped to complete this work and
- To the staff of ULK Polytechnic Institute

ACKNOWLEDGEMENT

This Final Project's success and completion are attributed to several people and organisations. I want to express my profound gratitude to the All-Powerful God for his protection. I also want to express my gratitude to everyone who has supported us in any manner and given it their all to help us become the men I am today

I especially want to praise the Rwandan government for its commendable strategy of encouraging education at all levels. I extend my heartfelt gratitude to the whole academic staff and management of ULK Polytechnic Institute. I profoundly thank my supervisor, Engr. Bonaventure NKIRANUYE, for his insightful and technical recommendations, revisions, and guidance that helped this research effort succeed.

My sincere gratitude is sent to our family, my brothers and sisters, for their wise counsel and prayers over our education, which have strengthened me, and to my parents for their various forms of financial support and problem-solving assistance.

Lastly, I would like to thank everyone for their contributions and assistance in helping us to complete my studies successfully.

MPAMBARA Antoine

ABSTRACT

This dissertation is a detailed study entitled "**Architectural and Structural Design of Three-Storey Modern Market Building:** Case Study of Gasabo District." The object in question is a three-storey modern market building measuring 52.153 length x42.995 width with main features

like balconies, washrooms, bedrooms, verandahs, and kitchens. Each floor stands

at a height of 3.80 m.

The structural analysis applied general principles in civil engineering to carefully design

key items such as beams, slabs, columns, foundations, and stairs. The longitudinal had a depth of 800 mm and a width of 300 mm, with a wing width of 907 mm using Ø40 mm reinforcement bars both on the upper and lower sides. Slabs were divided into three categories, namely continuous and discontinuous. Slabs had 15 cm thickness and were supported by Ø12 mm reinforcement bars.

Columns of the mix contained Ø40 mm bars with Ø8 mm links at 144 mm centre to centre.

The bearing capacity Pb = 400 KN/m 2 was used for the foundation design, which gave the foundation dimensions 4000*4000*500 mm, reinforced with Ø20 mm bars as the significant reinforcement. Stairs providing access between the floors were constructed with a going of 305 mm and a riser of 160 mm. The flights rose 200 cm with a pitch of 29.53 0. The reinforcement included Ø16 mm bars at the bottom and Ø8 mm bars at the top.

This dissertation presents a detailed study of the structural details involved in the construction of a three-story apartment building. It gives insight into the best construction practices through careful analysis and design, considering a context that differs from any other: the Gasabo District.

Keywords: structural design, three-storey modern market building, Gasabo District, beams, slabs, columns, foundations, stairs, reinforcement bars, civil engineering principles, geotechnical study.

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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.

As: Area of compression reinforcement.

As' prov: Area of compression reinforcement.

Asc: Area of steel in compression

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

bw: Average web width of a flanged beam

d: Depth to the compression reinforcement.

d: Effective depth of the tension reinforcement.

fcu: Characteristic strength of concrete.

fy: Characteristic strength of reinforcement

G: Going

Gk: Characteristic dead load.

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

hf: Thickness of the flange.

K: Factor

l: Span of the beam.

le: The effective height of a column in the bending plane is considered.

lx: Length of shorter side.

lx: shorter span of flat slab panel.

ly: length of the longer side.

ly: longer span of flat slab panel.

M: Design the ultimate moment at the section considered.

Msx: bending moment in x direction

Msy: bending moment in y direction

Mx: moment on the column in x direction

N: Design axial force.

ϕ: diameter of steel.

Pmax: maximum pressure on footing

Pmin: minimum pressure on the footing

Qk: characteristic imposed load.

R: Riser

Sv: spacing of links along the member.

V: Design shear force due to ultimate loads.

V: Shear stress

V_C: Shear capacity of concrete

Vsx, Vsy: Design shear capacity of shear reinforcement

W: self-weight of the foundation

X: depth to the neutral axis.

Z: a lever arm

CHAPTER ONE: GENERAL INTRODUCTION

1.1. Introduction

In this respect, my architectural and engineering team proudly presents an inclusive study and design proposal for a three-storey modern market building in response to the increasing demand for an urban modern market within the Gasabo District, Gasogi Sector. Therefore, the rationale behind this proposed undertaking directly relates to the dire need for economically affordable, non-hazardous, and attractive dwelling solutions in this thriving and fast-evolving community. The Gasabo District, in the heart of Rwanda, has encountered remarkable urban growth.

Recently, it has acted upon through economic development and an increase in population. This has resulted in increased demand for housing; more so, the Gasogi Sector has become one of the prime modern market areas due to its proximity to amenities, education, and employment opportunities. Our project recognises the critical role that a well-designed modern market plays in improving residents' quality of life and contributing positively to sustainable urban development.

This document serves as an introductory overview of the structural design proposal for the three-storey modern market building that will contribute to the ongoing urbanisation and development of the Ndera Sector. It outlines the key considerations, objectives, and design principles guiding our project. The proposed structure will provide much-needed modern market units and set a benchmark for sustainable and aesthetically pleasing architecture within the district. The following sections will delve into the specific design aspects, including the site analysis, architectural concept, structural system, materials, and sustainability features that will define this project. Our team has strived to combine functionality, safety, and aesthetics to create a building that harmonises with its surroundings while meeting the diverse needs of its future inhabitants.

This three-story modern market building's structural design aims to combine state-of-the-art engineering methods with a thorough comprehension of the regional climate, culture, and

This three-story contemporary market building's structural design aims to combine state-of-the-art engineering methods with a thorough comprehension of the regional climate, culture, and building customs. Through this process, we hope to build a sturdy and effective building that will endure and enhance the Gasabo district's urban landscape. In order to make the idea of contemporary, sustainable urban living a reality for the people of Ndera Sector, a team of architects, structural engineers, environmental specialists, and urban planners worked together on this project. We will thoroughly explain our design approach in the following pages, ensuring that every facet of the structural design complies with the particular needs and goals of the community and The overarching objectives of sustainable urban development. As we start on this thrilling adventure to mould the future of Gasabo District, we welcome all stakeholders, from local officials to potential no-developed ones, to participate in achieving this ambitious initiative. Collectively, we can establish a lively, adaptable, and peaceful living space that honours the essence of the Gasogi Sector and nurtures a feeling of community and connection for future generations.

1.2. Background of the study

The modern market is significant in the establishment in the community throughout the world; there are a lot of modern markets where significant commodities are being sold, and the market exists to fulfil a public purpose, The foremost basic in structural engineering is the design of simple basic components and members building, i.e. slab, beams, columns and footings who are a community unique character and culture while serving its every day shopping needs Gasogi. (Melvern L. , 2024)

Due to a large Population and also pimp the market that is why we need Gasogi to construct a new modern market. The foremost basic in structural and architectural engineering design is the design of simple essential components and members of the building .e.Slab, Beam, Columns and footing (Li, 2023)

It would be strange to think that the global market landscape would stop evolving because it never will. It is a constant. Technological advances—such as AI and the continual shift towards digital platforms have reshaped how businesses connect with their audiences

Brands and localisation companies alike have to lean in and adapt to the evolving landscape and technologies. And (McNeill, 2016)

• A shift in consumer behaviour influenced by factors such as the pandemic,

• The growth of e-commerce—accelerated by the COVID-19 pandemic—reshaping the retail landscape.

• The influence of social media, which now plays a significant role in shaping consumer opinions and driving brand awareness.

Increased conflict in Africa, tensions and conflict in the Middle East and Ukraine, medium-term climate change catastrophes, as well as calamities from inadequately controlled transformational artificial intelligence (AI) (Găman, (2024))

Continental-scale The Single Market was established to strengthen European integration by eliminating trade barriers and ensuring fair competition, and the Single Market proved from the beginning to be a formidable boost for the European economy, It facilitated the free movement of goods, services, people, and capital through harmonisation and mutual recognition, thereby enhancing competition and fostering innovation. Furthermore, cohesion funds were introduced to guarantee that all regions could equally benefit from market opportunities. This comprehensive approach has been pivotal in driving economic integration and development across the European Union. Tailored for the world of that time, the Single Market proved from the beginning to be a formidable boost for the European economy and a powerful factor of attractiveness. (Ciornei, 2021)

In the region scale, fortunately, analysts have seen positive earnings and revenue growth for all eleven market sectors this year. The healthcare sector is expected to generate a market-leading 17.8% earnings growth in 2024 (Turban, 2021)

National scale in Rwanda is a small but growing market, with a population of 13.7 million people and a Gross Domestic Product (GDP, Current) of $13.3 billion, according to the World Bank. Before the COVID-19 pandemic, Rwanda enjoyed strong economic growth, averaging over seven per cent GDP growth annually over the last two decades. The Rwandan economy grew 8.2 per cent in 2022 thanks to strong growth in industry, construction, services, and agriculture. (Spielman, 2023)

1.3 Problem statement

Gasabo is a district that is developing commercial and other different trades like transport, raising or bleeding, and agriculture, but also that district has more than one market, which is needed to satisfy the people. This is the problem with trade because people, to reach the market, need to traverse long distances to the populations.

According to this project, after observing the problems of the one market at Gasogi, in the Ndera sector of the Gasabo district, we propose to construct another market that is very good and safe and has enough space to satisfy the trades and customers in case of movement and good security this market will help to improve economic of the district as well as the country

1.4 Objectives of the study

1.4.1 Main objective

The main objective of this study is to do the structural design of a modern market with three storeys.

1.4.2 . Specific objectives

The specific objectives are :

- ✓ To provide the architectural drawing
- ✓ To provide the structural drawing
- ✓ To determine the total load supported by the building's Foundation, slab, columns, and beams
- ✓ To provide the cost of estimation of the building

1.5 Research question

After conducting interviews with individuals from the Gasogi Sector, the research queries arose as a crucial aspect. The subsequent inquiries are as follows:

1. What is the number of individuals in your community who seek the advancement of the area? 2. How can all community members reap the benefits of this initiative?

3. What is your recommended timeline for the execution of this project, and what is the rationale behind it?

4. Have you comprehended the details of this project?

5. What level of involvement do you anticipate from the government and your community to ensure the successful implementation of this project?

1.6 Hypothesis

The hypothesis is a provisional statement that serves as the basis for conducting experiments or investigations. It consists of assumptions that are temporarily accepted. The hypotheses to be tested are as follows:

H0: The structural design of the modern market at Gasogi has led to the availability of safe, comfortable, sustainable buildings and improved living standards in the Ndera sector.

H1: The structural design of the modern market at Gasogi has led to the availability of safe, comfortable, sustainable buildings and improved living standards in the Ndera sector. The acceptance or rejection of the hypothesis will be determined based on the sample obtained from interviews conducted with different people. This will be supplemented by the results obtained from the hypothesis testing.

1.7. Significance of the study

1.7.1. Society interest

After conducting interviews with individuals from the Ndera Sector, the research queries arose as a crucial aspect. The subsequent inquiries are as follows:

1. What is the number of individuals in your community who seek the advancement of the area? 2. How can all community members reap the benefits of this initiative?

3. What is your recommended timeline for executing this project, and what is its rationale?

4. Have you comprehended the details of this project?

5. What level of involvement do you anticipate from the government and your community to ensure the successful implementation of this project?

1.7.2. Researcher interest

- Enhancing professional skills - Enhancing proficiency in CAD software

- The research will provide valuable insights into this project, contributing to the improvement of knowledge for both my colleagues and me.

- This study will facilitate the researcher in gaining more familiarity and experience in managing similar projects post-graduation

1 7 3 Research interest

- This report can serve as a fundamental guide for future researchers and academic references.

This report can be utilised as a reference document for hotel projects in various locations around the world by any individual.

- Students and teachers can also use this report as a reference point for hotel projects.

- The findings from their study will be utilised for additional research.

1.8 Scope and limitations of the study

The project will be limited only to the conception and design of the structure elements and architectural drawing, including foundation plan, floor plan, elevation plans, roof plan and section plans. We shall end it with the cost estimation.

The metallic roofing trusses, slabs, beams, columns, footings, and stairs in Reinforcement Concrete Cement were analysed for design and structures. The following tasks were omitted:

We will use the results of studies conducted on similar buildings in the Gasabo District for soil analysis.

Topographic surveying is unnecessary as the plot is flat and does not require topographic plans. Due to time constraints, the Bill of Quantities was not prepared

1.9 Organisation of Study

This study will consist of five primary chapters to ensure clarity and cohesion in discussing all the investigations conducted on the "Structural design of a three-storey modern market building; Case study: Gasabo District, Gasogi Sector."

CHAPTER ONE: General introduction, encompassing the introduction, problem statement, research objectives, research benefits, research scope, research hypothesis, and overall research structure.

CHAPTER TWO: Review of literature to provide comprehensive details and theories related to the design of reinforced concrete buildings and to identify the factors influencing their strength.

CHAPTER THREE, Materials and Methods, covers the procedures, methods, definitions of the instruments used in the investigations, and strategies and methods for gathering all the necessary data.

CHAPTER FOURResults and discussions, covering the findings' presentation, analysis, and interpretation, make up

CHAPTER FIVE, Conclusions and Recommendations, summarises the research's findings and makes recommendations

CHAPTER 2.LITERATURE REVIEW

2.1. Introduction

This chapter reviews the literature on the concept and design of a three-story Modern market building and the literature relevant to it. The literature used in this study is primarily based on writings by various authors regarding the structural and architectural layout of a modern market building. This literature review aims to fill in any gaps that various authors may have missed to increase our knowledge of the structural and architectural design of modern market buildings.

2.2. Structure made of reinforced concrete

This composite material has steel bars mixed with the concrete to give it certain desired qualities. It is vital to remember that while steel is good in both tension and compression, it corrodes easily if it is not well-protected, and it yields quickly at extremely high temperatures. Mass concrete is fragile in tensile forces (tension), strong in compression, and can withstand fire. Therefore, a structural engineer can greatly benefit from combining two materials to form a single composite substance. They thus come together and fulfil the required qualities. For example, the structure designed by a structural engineer's strength, durability, etc.

2.2.1. Concrete

, Fine Aggregate, water, and coarse aggregate,cement are the ingredients of plain concrete. When the concrete is still fresh, the components of the plain concrete are combined to form a paste that encloses the aggregate voids. After the steel bars are positioned inside the firms, the concrete paste is poured around them and allowed to solidify for approximately 24 hours, hardening the concrete. The concrete components impact the expected results, which are supposed to provide accurate data as intended initially. Additionally, strong agreement is anticipated in the tests conducted after 7, and 28 days for compressive strength, modulus of elasticity, and Poisson's ratio. Consequently, the high-quality homogenous material provides a good

2.2.1.1. Concrete type selection

The strength needed, which is dependent on the amount of loading as well as the shape and dimensions of the structural components, often determines the type of concrete that should be used. For instance, high-strength concrete may be preferred in the lower columns of a multi-story building over significantly enlarging the column section, which would result in a loss of usable floor space. As previously mentioned, the crushing strength of concrete or concrete cylinders made from the mix is used to determine the strength of the concrete. Standard protocols call for these to be cured and tested after 28 days. A concrete's class indicates what strength it is.

Table 2.1: Different grades of concrete and mix ratio

Grades of Concrete	Ratios of Concrete mix (Cement:Sand:Aggregate)
M5	1:5:10
M7.5	1:4:8
M10	1:3:6
M15	1:2:4
M20	1:1.5:3
M25	1:1:2
M30	1:0.75:1.5
M35	1:0.5:1
M40	1:0.25:0.5

Mix design and class or grade of concrete may also be concerned with conditions of exposure and durability. A structure to be used under corrosive conditions in a chemical plant would call for denser and higher-class concrete than, say, interior members of a modern market or office.

2.2.1.2 Ingredient of concrete

- **Cement**

The cementing material is defined as a substance that has the adhesive properties by which it can hold fragments of other substances together in a compact mass. Cement nowadays is a product obtained by burning a mixture of clay and limestone in a kiln at 1400–16,000°C (IS: 1343-1980 (Clause 4.1)

.The most generally used kind of Portland cement is regular use. Its main ingredients include iron oxide, silica, alumina, and lime. All these ingredients are first crushed, mixed in appropriate

portioprons and then burned in a rotating kiln. Clinker is then mixed with gypsum and ground into an extremely fine powder to produce cement. The primary chemical components of cement are calcium silicates and aluminates. When water is added to cement, certain chemical reactions take place in the cement paste, and the mixture eventually solidifies and stiffens. The previously mentioned gypsum controls or delays the setting time, preventing the concrete from setting too quickly and impeding construction or setting too slowly .

2.2.1.3 Types of Portland cement

I. **Ordinary Portland cement** is a general-purpose type used to manufacture masonry units, buildings, bridges, and pavement composed of ordinary concrete.

II. Modified In contrast with type I, Portland cement produces less heat during the setting process. Heat liberated by the hydration reaction can have damaging effects on concrete if it occurs in large quantities.

III. Elevated early potency As its name implies, Portland cement is employed immediately when significant strength is required. This might be the result of a desire for early usage in cold-weather buildings to shorten the time that low or freezing temperatures provide protection.

IV. Low-temperature Portland cement has type II heat resistance, albeit to a greater extent. Although it gains strength more slowly than type I, it aids in keeping the structure from reaching high temperatures, which increases the risk of thermal cracking as the structure cools down.

V. Resistant to sulphates: When strong sulfate resistance is required, Portland cement is utilised because it has a higher degree of sulphate resistance than type

VI. Pozzolan cement combines cement clinker and pozzolans in a 15—to 40% ratio. Pozzolan, also known as fly ash, volcanic ash, diatomaceous, or calcined shale, is a siliceous and aluminium substance. Its workability may be superior for some applications, but its strength is not as high as concrete prepared with the same amount of Portland cement.

VII. Air-entrained cement concrete is resistant to frost action, and salts are used in ice and snow removal processes. It is made by including an air-releasing substance in the ground clinker (Feng, 2023).`

2.2.2 Aggregates

Since aggregates make up approximately 75% of the volume of concrete, their characteristics greatly affect the characteristics of concrete (Alexander and Mindess, 2005). Granular materials called aggregates are often crushed stone, sand, or gravel from nature, while synthetic materials like slags, expanded clays, or shales are also infrequently utilised.

While most aggregates have specific gravities between 2.6 and 2.7, unique concretes can occasionally use both heavyweight and lightweight aggregates, as will be discussed later. Without aggregates, massive castings of neat cement paste would almost self-destruct upon drying. Aggregates play the role of providing significantly superior dimensional stability and wear resistance. Additionally, aggregates are less expensive than Portland cement, which results in the development of more cost-effective concrete mixtures, which is essential. Generally, aggregates possess significantly greater strength than cement paste, rendering their precise mechanical properties less critical, except for ultra-high strength concretes. Furthermore, aggregates are typically regarded as entirely inert within a cement matrix; however, this assumption does not hold true in all instances, particularly concerning the alkali-aggregate reaction, which will be elaborated upon later. For standard concrete applications, the key properties of aggregates include particle grading or size distribution, shape, and porosity, along with their potential reactivity with cement. All aggregates must be clean, meaning they must be devoid of contaminants such as salt, clay, dirt, or any foreign substances. For practical purposes, aggregates are commonly categorised into two size ranges: coarse aggregates, which consist of the material retained on a No. 4 sieve (4.75 mm) The fine aggregate is defined as the portion that passes through a No. 4 sieve while being retained on a No. 100 sieve, which has an opening size of 0.15 mm. , (Bustillo Revuelta, 2021)

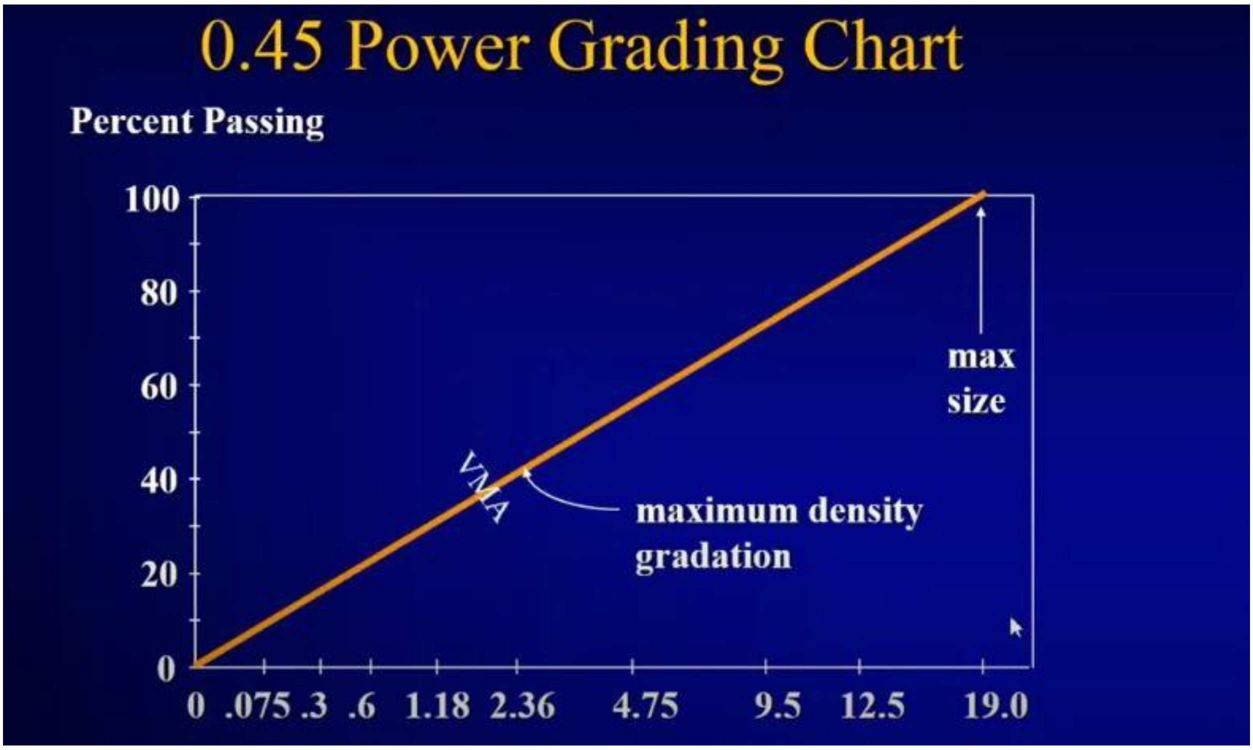

Figure 2.1 Aggregates zises

2.2.2.1.Aggregate sources

can be classified into natural and manufactured categories. Natural aggregates originate from rock, which can be broadly categorised into three geological types (Hartmann, 2012)•

Igneous rock: Characterised by a primarily crystalline structure, these rocks are formed through the cooling of molten rock material beneath the earth's surface.

• **Sedimentary rock**: These rocks are created from deposited insoluble materials that undergo transformation into rock through the application of heat and pressure.

• **Metamorphic rock**: This category includes igneous or sedimentary rocks that have experienced significant heat and/or pressure, resulting in alterations to their mineral composition compared to the original rock. To maximise the amount of aggregate within a specific volume and achieve optimal packing density, it is essential to utilise a range of aggregate sizes to occupy as many voids as possible effectively.

The selection of aggregate sources for concrete is contingent upon the intended application of the final product. The types of aggregates can be categorised as follows: natural aggregates, lightweight aggregates, and heavyweight aggregates.

Natural aggregates are sourced from naturally occurring deposits, which can be located in gravel beds on land or in marine environments. Additionally, larger parent rocks may be crushed to achieve dimensions appropriate for concrete use. The resulting particles from rock crushing tend to be sharp and angular, contrasting with the naturally rounded particles found in gravel. Rounded gravels, typically obtained from river valleys or shallow coastal areas, necessitate washing, grading, and crushing of oversized materials to meet the requirements for concrete production.

Lightweight aggregates are utilised to create low-density concrete mixtures. Lightweight aggregates (LWAC) offer significant benefits in minimising the self-weight of structures while also providing superior thermal insulation properties compared to conventional concrete. The lower density of these aggregates is attributed to the voids present within the aggregate particles. Currently, the majority of lightweight aggregates are produced artificially. Artificial lightweight aggregates are available in both coarse and fine forms, exhibiting reduced density due to increased porosity, which consequently leads to a decrease in the overall strength potential of the concrete. These lightweight aggregates possess a lower density than standard-weight aggregates, and their reduced elastic modulus results in concrete that exhibit a lower elastic modulus along with increased creep and shrinkage. The densities of concrete utilising lightweight aggregates can vary from approximately 300 to 2000 kg/m^3. In contrast,

heavyweight aggregates are employed when high-density concrete is necessary, such as in applications requiring radiation shielding. This type of concrete can achieve densities ranging from 3500 to 4500 kg/m^3. Aggregates may exist naturally in terrestrial and coastal deposits, which experience weathering processes. Those naturally deposited through various weathering such as water, wind, or glacial erosion are relatively easy to extract. They usually require only washing and grading before being applied. These types of aggregates are called gravel aggregates. On the other hand, rock is quarried from a quarry site and crushed to the required size.

2.2.3 Water

Mixing water

1. Water is a fundamental component in construction, yet the quality of this essential element is often overlooked. It is necessary for the preparation of mortar, the mixing of cement concrete, and for curing processes during construction. The quality and quantity of water significantly influence the strength of both mortar and cement concrete.

Water is crucial in the concrete mixing process, serving primarily to enhance workability and initiate hydration. Any substances present in the water that hinder or alter the hydration process can be harmful. Many specifications stipulate that the water used should be potable, although this is not an absolute requirement; certain chemicals found in drinking water may be harmless to human health but detrimental to concrete. Nevertheless, as a general guideline, it is advisable to use potable water for concrete applications, commonly referred to as ordinary water.

The substances present in certain types of water may include organic compounds, oil, alkali, or acid, each of which influences the hydration process in distinct ways. Organic materials and oil can form a coating on aggregate and cement particles, hindering the complete chemical reaction and bonding. Additionally, organic matter may interact with the cement's chemicals, leading to a compromised cementing effect, which can ultimately result in the deterioration and structural failure of the concrete. Alkalis, acids, and sulfates found in water can also react with the cement's components, leading to insufficient cementing and weakened concrete. Therefore, it is essential that water used for concrete mixing is devoid of these harmful chemicals. Regarding seawater, while the salts it contains are generally considered corrosive, it is occasionally utilised in concrete mixing with acceptable outcomes. When seawater is employed, a reduction in compressive strength of approximately 10 to 20% can be anticipated. This loss can be mitigated by adjusting the water/cement ratio accordingly.

The quality of water utilised for mixing and curing must be pristine and devoid of harmful quantities of alkalis, acids, oils, salts, sugars, organic materials, plant growth, and other substances that could adversely affect stones, bricks, concrete, or steel. Generally, potable water is deemed adequate for mixing purposes. A pH value ranging from 6 to 8, which does not exhibit saline or brackish characteristics, is considered appropriate for use (Edward et al., 1997).

Curing water

Typically, water that is suitable for mixing is also appropriate for curing. Nevertheless, the presence of iron or organic matter may lead to staining, especially if the water flows slowly over the concrete and evaporates quickly. In certain instances, discolouration may be a concern, and any water deemed suitable for mixing, or even of slightly lesser quality, can be used for curing. It is crucial, however, that curing water is free from substances that can damage hardened concrete. For instance, water containing free CO_2 can be detrimental to concrete.

Tests on Water

A straightforward method for assessing the appropriateness of water for mixing involves comparing the setting time of cement and the compressive strength of mortar cubes made with the water in question against the results obtained using water of known quality, such as distilled or standard drinking water. According to BS 3148:1980, a tolerance of 10% is recommended to account for potential variations in strength. Such evaluations are particularly advised when the water in question has no prior service record and contains dissolved solids exceeding 2000 ppm or, in the case of alkali carbonate or bicarbonate, surpassing 1000 ppm. Additionally, testing is prudent when unusual solids are detected. (McManus, 2018)

2.2.4. Properties of Concrete

The primary characteristics of concrete are outlined below:

1 The compressive concrete strength

is stated in terms of the 150mm cubes' typical compressive strength, which is evaluated after 28 days (fck). The strength level below which no more than 5% of the test results are expected to fall is known as this characteristic strength. The underlying premise of this definition is that the distribution of the concrete samples is normal. The strength of the cubes after 28 days determines the characteristic strength, which is equivalent to the concrete grade.

To determine their strength, standard cubes of 150 mm or 100 mm—which are used for aggregates no larger than 25 mm—are crushed. The diagram that goes with it shows

an idealised distribution of compressive strength values derived from a significant number of test cubes. The horizontal axis denotes the compressive strength values, while the vertical axis indicates the frequency of test samples corresponding to specific compressive strength levels. The mean strength is represented as the average of these values. The characteristic strength (fck) is identified as the point on the x-axis below which 5% of the total area under the curve is located. The value of fck is calculated to be lower than the mean strength by 1.65 times the standard deviation (δ) of the normal distribution. (Volchuk, 2022)

2 Tensile Strength

While concrete is typically not engineered to withstand direct tension, understanding its tensile strength is essential for predicting the load at which cracking may occur. This knowledge is crucial as it affects both the initiation of cracks and their progression towards the tension side of reinforced concrete flexural members Furthermore, shear, torsional, and various other forces may generate tensile stresses in particular areas of concrete structures. The tensile strength of concrete is roughly one-tenth of its compressive strength. This can be measured through multiple methods.

- Flexural tensile strength is determined by testing beams subjected to two-point loading (or four-point loading, which includes the reactions).

- **Splitting tensile strength** is assessed by testing cylinders under diametric compression.

- Direct tensile strength is evaluated by testing rectangular specimens under direct tension. In the absence of empirical test data, codes suggest estimating the flexural tensile strength using the following equation: $fcu = 0.7\sqrt{fck}$.

Tensile strength is a crucial characteristic of building materials that has many benefits.

Structural Integrity: Materials with high tensile strength can resist pulling and stretching pressures, which improves the overall stability and longevity of structures.

Load-Bearing Capacity: Taller buildings and longer spans are possible without the need for additional reinforcement when structures composed of materials with high tensile strength are able to handle larger loads.

Material Efficiency: Lighter buildings and lower construction costs can result from using materials with high tensile strength, which can cut down on the quantity of material required.

Safety: Good tensile strength materials are less likely to break under tension, which lowers the possibility of a structural collapse and improves building and infrastructure safety.

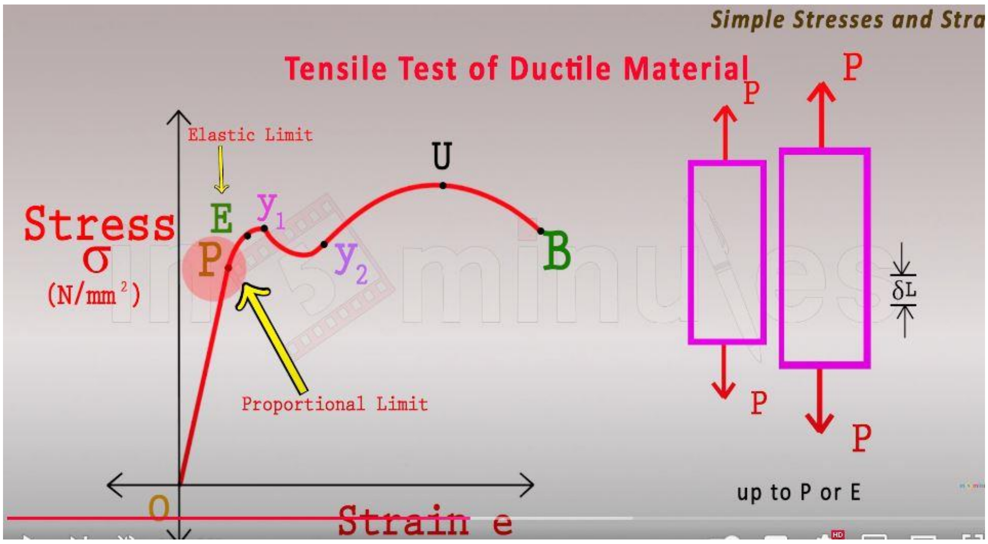

Figure 2.2 Tensile Test of Ductile Materials

a. Factors affecting the relationship between tensile and compressive strength

- ✓ Aggregate
- ✓ Age
- ✓ Curing
- ✓ Air-entrainment
- ✓ Light-weight concrete
- ✓ Method of test (von Davier, 2006)

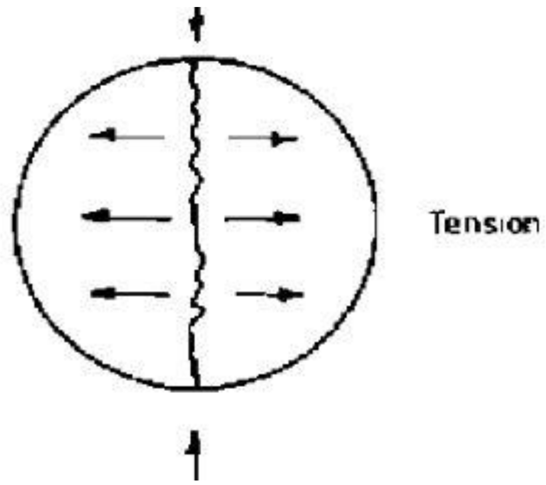

Figure 2.3 Cylinder Tensile Test

3. Modulus of Elasticity

The short-term stress-strain relationship for concrete subjected to compression is depicted in Figure 6. The gradient of the initial linear portion signifies the initial tangent modulus. At any specified point P, the slope of the curve reflects the tangent modulus, whereas the slope of the line connecting point P to the origin is known as the secant modulus. The value of the secant modulus is influenced by both the level of stress and the rate of load application. The dynamic modulus is determined by inducing longitudinal vibrations in a beam specimen. This resultant value is not affected by creep and is approximately equal to the initial tangent modulus illustrated. The secant modulus can be calculated from the dynamic modulus using the appropriate formula.

Types: There are different types of moduli:

Young's Modulus: Measures tensile or compressive stiffness.

Shear Modulus: Measures stiffness in shear.

Bulk Modulus: Measures stiffness under uniform compression.

Units: The modulus of elasticity is typically expressed in pascals (Pa), megapascals (MPa), or gigapascals (GPa).

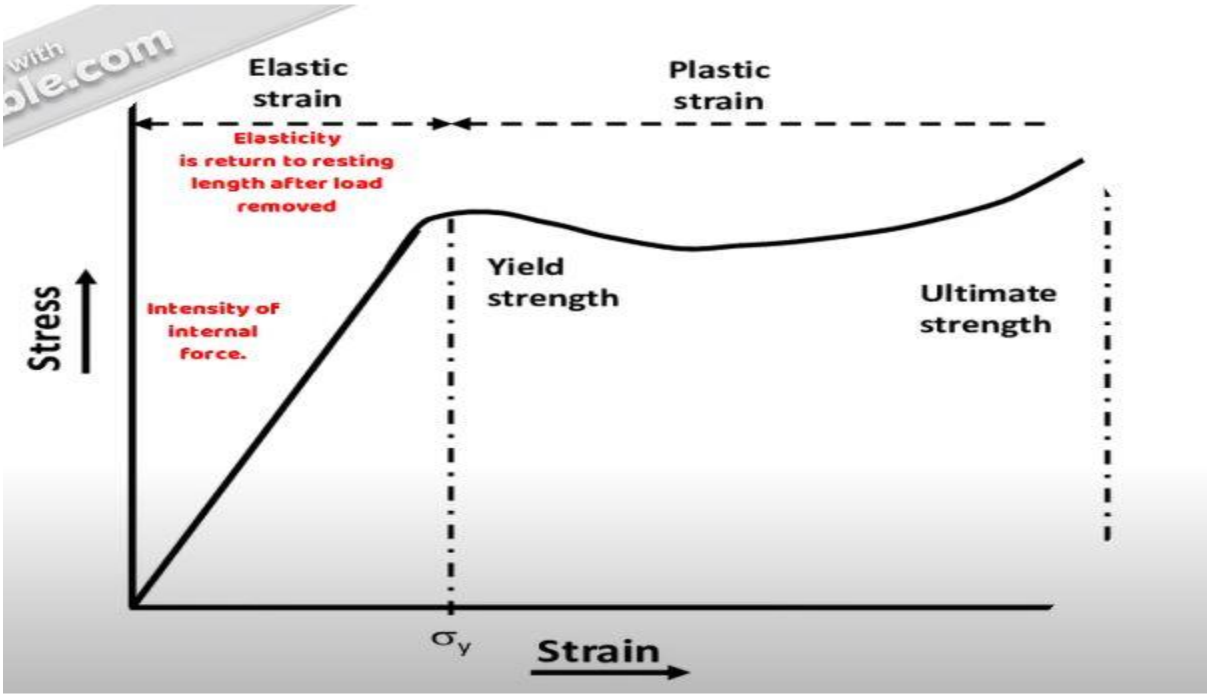

Figure 2.4 Modulus of Elasticity

4 **Creep**

Creep in concrete denotes the progressive increase in strain over time within a structural component that is subjected to continuous stress. The strain caused by creep is notably more pronounced than the elastic strain observed during the initial loading phase. When the load is removed, there is an immediate elastic recovery, succeeded by a slower recovery linked to the creep strain. Nevertheless, both types of recovery are significantly less than the original strains experienced while under load. The main factors that affect creep strain include the composition and strength of the concrete mixture, the type of aggregate utilized, the curing method, the surrounding relative humidity, and the magnitude and duration of the applied load. The creep strain εcc can be calculated using the creep coefficient ϕ, as expressed in the following equation, where Et signifies the modulus of elasticity. The creep coefficient ϕ of concrete during loading is ffected by several factors, including the effective thickness of the section, the age at which the loading takes place, and the ambient relative humidity.

5. Shrinkage

Drying shrinkage refers to the decrease in volume that concrete experiences as it cures and loses moisture. This phenomenon is permanent, in contrast to the reversible changes in volume that occur during cycles of wetting and drying, which can cause both expansion and contraction. The characteristics and proportions of the aggregate used are critical determinants of shrinkage behavior. Specifically, a higher content of larger aggregates tends to mitigate shrinkage effects. The dimensions of the aggregate play a crucial role in influencing shrinkage; larger aggregates are associated with diminished shrinkage and an increase in aggregate volume. In contrast, a lower water-to-cement ratio and reduced workability are linked to a decrease in shrinkage. Aggregates that experience volumetric changes during moisture fluctuations, such as sandstone or basalt, can induce significant shrinkage strain in concrete, while aggregates that do not shrink, like granite or gravel, lead to lesser shrinkage. Furthermore, a decline in ambient relative humidity can intensify the shrinkage process (Shahmirzadi, 2021).

2.2.5 Reinforcement :

Throughout history, humanity has endeavored to identify optimal materials for the construction of shelters and tools. A significant advancement in this pursuit was achieved with the introduction of iron into the production of steel, which greatly enhanced these objectives. Traditional construction materials, such as timber, often lacked sufficient strength, while stone and concrete tended to be overly cumbersome. In contrast, steel emerged as a material that effectively fulfilled many of the desired properties, resulting in its extensive use within the construction industry. Reinforcing bars are produced in two primary varieties: hot rolled mild steel bars, which have a yield strength of 259 N/mm^2, and high yield steel, available in both hot rolled and cold worked forms, exhibiting a characteristic strength of 460 N/mm^2. The mechanical properties of steel are generally evaluated through specialized testing methods, with the tensile test being the most common and straightforward approach. Reinforcing bars are categorized into two grades: hot rolled mild steel bars with a yield strength of 250 N/mm^2 and high yield steel bars, either hot rolled or cold worked, with a yield strength of 460 N/mm^2. Additionally, steel fabric, made from cold-drawn steel wires welded into a mesh, also demonstrates a yield strength of 460 N/mm^2. Hot-rolled bars are characterized by a distinct yield point. a defined proof stress characterises cold-worked bars.

The value of Young's modulus (E) is established at 200 kN/mm². (T.J. Mac Ginley and B.S. Choo,

A. Properties of steel reinforcement

The Characteristics of Steel Reinforcement To ensure robust, ductile, and long-lasting construction, the reinforcement must possess the following characteristics:

- Elevated strength

- Significant tensile strain (hight)

- Effective bonding with the concrete

- Compatibility with thermal conditions

- Resistance to deterioration in the concrete environment

. The stress-strain relationships for reinforcing bars are depicted in the accompanying figures.

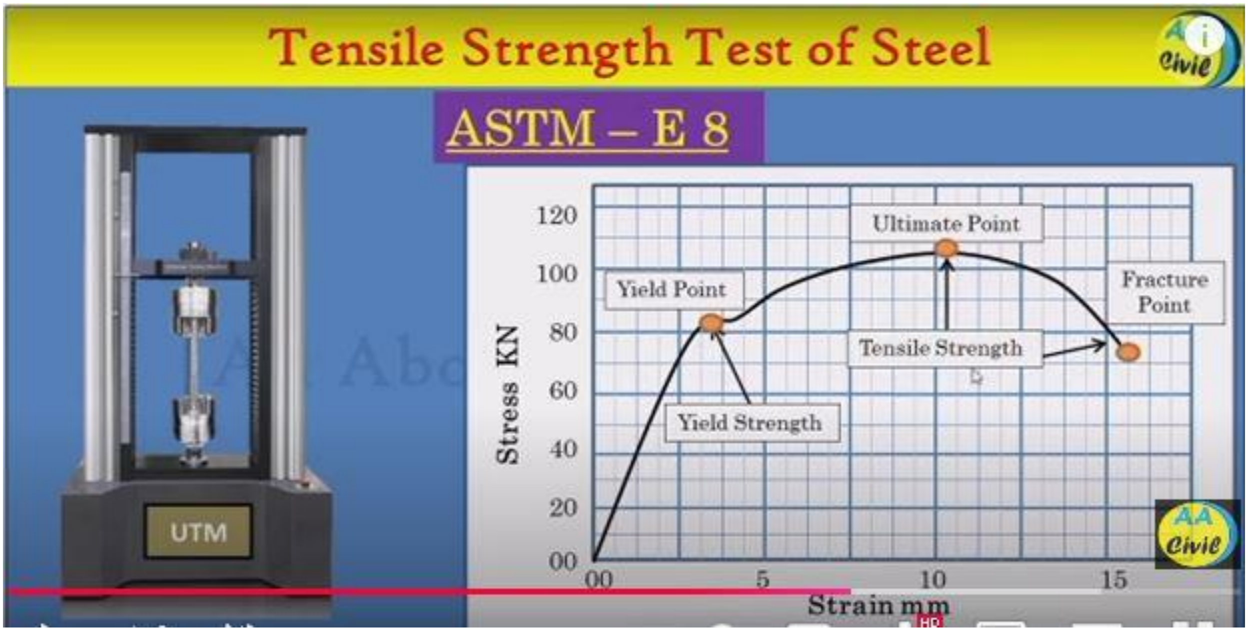

Figure 2.5 Tensile Strength Test of steel

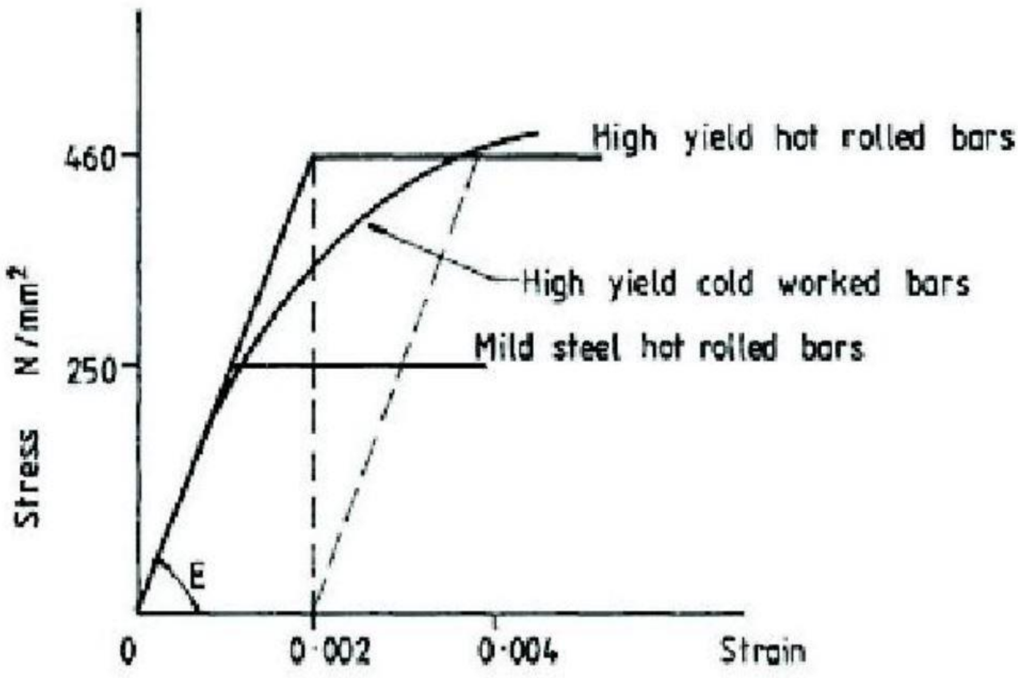

Figure 2.6 Stress-strain curves for reinforcing bar

The table presented below illustrates the strength of reinforcements in relation to the classification of the steel.

Table 2. 2 Strength of reinforcements (Bath, 2002)

Designation	**Nominal size (mm)**	**Specified characteristic strength (N/mm^2)**
Hot- rolled mild steel	All size	250
Hot- rolled high yield Cold-worked high yield	All size	460
Hard drawn steel wire	Up to and including 12	460

2.3 Function of a Structure

The primary role of any structure is to support loads and transfer forces. These forces can originate from various sources and are influenced by the intended use of the structure. For instance, in a multi-storey steel building, the steel framework is responsible for supporting the roof and floors, as well as the external walls or cladding, while resisting wind forces. The external walls serve to protect the building's interior and convey wind loads through the floor slabs to the framework, whereas the roof bears snow and other loads that are similarly transferred to the frame. Additionally, the floor slabs are designed to support occupants, furniture, and floor coverings, among other elements.

Load: A load is pretty much a force that a building or structure needs to be able to resist. Loads cause stresses and deformations to a structure and it is my job to make sure that a structure or part of the structure does not fail when these loads are applied. Loads can be applied vertically or laterally on a structure.

2.3. 1 Types of load

Dead load

Live loads

Wind load

Imposed loads

Dead loads : also known as permanent or static loads, are those that remain relatively constant over time and comprise, for example, the weight of a building's structural elements, such as beams, walls, roof and structural flooring components.

Dead load: The weight of a building refers to a structure's static, non-moving weight or any permanent components that form an integral part of it. It primarily consists of the weight of the building materials and any fixed installations, such as walls, beams, columns, roofs, and flooring

Live loads are also called imposed loads. They are either moving loads or movable loads that do not have any impact or acceleration. All these loads are part of what an occupant brings into the building. These items are normally furniture and movable partitions.

Live load is a civil engineering term for a load that is not constant but changes over time. It can be caused by anything adding, removing, or relocating weight on a structure. This includes people walking across a surface and objects that can be moved or carried.

Wind loads refer to the pressure caused by the wind that is delivered to a structure. This weight is dispersed over the structure's total area. Larger structures are more affected by the wind than small ones because the intensity of this load increases as building altitude increases.

Imposed loads are temporary, changeable or dynamic loads acting upon a structure. The magnitude of these loads is typically related to the occupancy of the space or building where the load is applied. For example, the imposed loads in an industrial facility will be different from those in a residential building.

Partial factor of safety for loads

Table 2.3 Load combination (Bath, 2002

Combination	Dead Load Max DL	Dead Load Min	Live Load L L	Water	Earth Pressure	Wind Load WL
1. DL + LL	1.4	1	1.6	1.4	1.4	-
2. DL + WL	1.4	1	0	1.4	1.4	1.4
3.DL+LL+WL	1.2	1.2	1.2	1.2	1.2	1.2

Load combination

Dead loads +imposed loads=

1.4GK+1.6QK

Dead loads+wind loads

1.4GK+1.4WK

Dead load+imposed loads+wind loads

1.2GK+1.2QK+1.2WK

2.4 Commercial building

Commercial buildings are buildings that are used for commercial purposes and include office buildings, warehouses, and retail buildings (e.g. convenience stores, 'big box' stores, and shopping malls). Commercial buildings support commerce, trade, professional services, offices, retail stores, restaurants, hotels, warehouses, industrial facilities, shopping complexes, healthcare facilities, hospitals, educational institutions, and entertainment venues. (Mohamad, 2022)

2.4.1 Modern market building

Gasogi Modern Market in Rwanda aims to promote local trade and foster community involvement. Its notable attributes encompass:

Sustainability: Implementation of environmentally friendly materials and energy-efficient technologies. Flexibility: Versatile areas accommodating diverse vendors and events. Technology Integration: Advanced systems facilitating inventory management and customer engagement. Community Focus: Assistance for local enterprises and cultural activities. Accessibility: Crafted to ensure inclusivity for all patrons.

2.5 Drawings

In construction, a drawing functions as a visual depiction that communicates the design, measurements, and specifications of a building or structure. It acts as a reference for architects, engineers, and builders, detailing aspects such as layout, materials, and construction techniques. Drawings play a crucial role in ensuring precise communication and promoting the effective implementation of construction projects. Would you be interested in delving deeper into particular categories of construction drawings?

2.5.1 Types of Architectural Drawings

Foundation Plan

A foundation plan is a drawing that shows the layout, dimensions, and details of the foundation of a building. It is an essential part of any construction project, as it provides the basis for the structural design and stability of the whole structure (Chazal, 2016).

Elevation Plan

An elevation plan provides us with an idea of what the finished building will look like. It is a visual representation of the exterior sides of a building, illustrating the structural and architectural details. In some cases, these plans can also illustrate the interior of a building. The elevation plan is composed of: a front view, Back view, Right view, Left view (Marfai, 2021)

Floor Plan

In architecture and building engineering, a floor plan is a technical drawing to scale, showing a view from above of the relationships between rooms, spaces, traffic patterns, and other physical features at one level of a structure.

Types Section Plan

Transversal section

Longitudinal Section

Perspective Plan

Perspective planning refers to long-term planning where targets are fixed for a long period, say 15 to 25 years. However, it does not imply one plan for the entire period. In a true sense, broader objectives are to be achieved in a fixed period by dividing the perspective plan into short-run plans of 4 to 6 years.

Finishing Drawings Finishing drawings include floor patterns, type of floor, paint colour, false ceiling, etc. They illustrate the aesthetic value of the building and also include other finer details of the building.

2. 6 Foundation

These shall include any type of building or a part of a building in which is used shops, warehouses, and markets for the display and sale of merchandise either wholesale.

Foundation, which is part of a structural system that supports and anchors the superstructure of a building and transmits its loads. Dead load and live load directly to the earth. To prevent damage from repeated freeze-thaw cycles, the bottom of the foundation must be below the frost line.

Good foundation requirements

i. The design and the construction of the foundation is done such that it can sustain as well as transmit the dead and the imposed loads to the soil. This transfer has to be carried out without resulting in any form of settlement that can cause stability issues for the structure.

ii. The foundation base should be very rigid so that differential settlements are minimised, especially in the case when the super-imposed load is not evenly distributed

2.6.1 Types of Foundation

Shallow Foundations.

Deep Foundations.

Pile Foundations.

Raft or Mat Foundations.

Strip Foundations: One of the Common Types of Foundations.

Pad Foundations.

Grillage Foundations.

Combined Footing Foundations.

2.6.2 Types of Deep Foundations

Pile Foundations.

Caisson or Well Foundations.

Basement Foundation.

Buoyancy Raft.

Shaft Foundations.

Some shallow foundation

Cantilever or strap footing

Continuous footing

2.7 Columns

Columns in civil engineering can be defined as vertical structural elements that act as supports and primarily support axial compressive loads. They are slender members designed as a support to hold the ceiling and roof, and the weight acting on them.

Classification of column

Short columns are defined as those for which the ratios lex/h and ley/h are both below 15 for braced columns and below 10 for unbraced columns. Conversely, slender columns are characterized by ratios that exceed these specified thresholds.

Short columns have a slenderness ratio of less than 32. Such columns are always subjected to direct compressive stress only. The medium column slenderness ratio is between 32 to 120. Long columns have a slenderness ratio of more than 120. columns can be broadly classified as short and slender columns based on their slenderness ratio. The slenderness ratio of a concrete column is defined as the ratio of its effective length le to its least lateral dimensions.

2.7 Beams

A beam serves as a fundamental structural component that predominantly withstands lateral loads acting along its axis. The primary mechanism of deflection in a beam is bending, which occurs as external loads generate reaction forces at the support locations, leading to the development of internal bending moments, shear forces, stresses, strains, and resultant deflections.Types of beam

The primary types of beams in engineering are

- the cantilever beam,
- simply supported beam
- overhanging beam, fixed beam,
- continuous beam

- Propped cantilever beam,
- and the trussed beam.

2.8 Slab

A concrete slab serves as a prevalent structural component in contemporary architecture, characterized by a flat, horizontal surface composed of cast concrete. Typically, steel-reinforced slabs, with thicknesses ranging from 100 to 500 mm, are predominantly employed in the construction of floors and ceilings. In contrast, thinner mud slabs are often utilized for outdoor paving applications (Townsend, 2023).

Classification of slab

Various categories of slabs exist, such as one-way slabs that support loads primarily in a single direction; two-way slabs that distribute loads across two dimensions; joist slabs characterized by concrete ribs providing additional support; and precast slabs, which are fabricated in a separate location before being delivered to the construction site. (Wang, 2023)

2.9 Stairs

Stairs are structures designed to bridge a large vertical distance between lower and higher levels by dividing them into smaller vertical distances. This is achieved as a diagonal series of horizontal platforms called steps, which enable passage to the other level by stepping from one step to another.

Types of stairs

The most common types of stairs are straight stairs, circular stairs, spiral stairs, switchback stairs, winder stairs, split stairs, and stairs with intermediate landings (Lu, 2021).

Construction estimating is calculating all of the required costs for a construction project, including direct costs (e.g. materials and worker wages) and indirect costs (e.g. equipment depreciation and office worker salaries).

Units of measurement

Single items like doors, windows, etc are expressed in number

Linear measurements that involve length, width, breadth, depth, height, and thickness, like cornice, etc, are expressed in running meter (m)

Areal measurements that involve areas like plastering painting, ceiling, etc, are expressed in meters squared (m^2) or sqm

Cubical measurements that involve volume, like excavation concreting walling, are expressed in cubic meters (m^3)

Factors affecting estimate cost

- Project size

- Project type project scope

- Project location, transportation duration

- Complexity of the project /project design

- Current exchange rate

- Unexpected expenses

- Government regulation

- Inflation

Types of estimation

-Detailed estimate

Approximate estimate - (Zeng, 2014, June)

Pre-Build Expenses 1.1. Purchasing Land Purchase Price: The price paid to purchase land in Gasogi. Zoning laws, size, and location can all affect prices. Legal Fees: Expenses related to the legal procedures for land purchase. Site Surveys: Land surveys, environmental impact studies, and geotechnical surveys' costs. 1.2. Planning and Design Architectural Fees: The price of employing engineers and architects for planning and design work. Fees associated with applying for and receiving the required permits and approvals from local authorities.

Consultation Fees: Expenses associated with hiring consultants with urban planning, sustainability, and market design expertise. 2. Building Expenses 2.1. Setting Up the Site Excavation and Clearing: The price of clearing the area, digging, and grading. Foundation Work: The price of constructing a three-story building's foundation. 2.2. Construction of buildings

Installations Tailored to the Market Establishing vendor stalls, kiosks, and shop units in the marketplace. Common Areas: Planning and building communal spaces like food courts, couches, and lavatories. Signage and Branding: The price of wayfinding systems, signage, and branding in the marketplace. 3. Costs of Operations 3.1. Furniture and Appliances Retail Equipment: The price of display units, shelving, point-of-sale systems, and other retail equipment. Furnishings: The price of adding seats, tables, and décor to communal spaces. 3.2. First Stock Stocking: If relevant, the first stock for market vendors. 3.3. Personnel and Education Staff Salaries: The price of employing and educating employees to run and manage the market. Administrative costs are the costs associated with running a business, including maintenance, marketing, and security. Other and Contingency Expenses

2.10. Methods Employed in Design

The preferred methodology is limit state design, which integrates theoretical insights, empirical data, and hands-on experience. This approach underscores the insufficiency of calculations alone in guaranteeing a structure's safety, functionality, and longevity. Equally important are the careful selection of materials, stringent quality control measures, and diligent supervision throughout the construction process. A key principle of safe design is that the structure must remain suitable for its intended use for the entirety of its expected lifespan, ensuring it does not reach a limit state during that time.

1. Design Objectives and Methodologies The central aim of design is to ensure a high probability that the structure will function effectively over its lifespan. It should adequately support expected loads, prevent excessive deformation, and exhibit sufficient durability against misuse and fire risks. This section recognizes that absolute safety cannot be assured for any structure; instead, the objective is to reduce the likelihood of failure to an acceptable level. The code promotes limit state design, which combines theoretical frameworks, experimental evidence, and practical experience. It emphasizes that calculations alone are

insufficient for guaranteeing a safe, functional, and durable structure, thereby highlighting the necessity of appropriate material selection, quality control, and oversight during construction.

2 Standards for Safe Design - Limit States The standard for a safe design stipulates that the structure must not become unfit for use, meaning it should not reach a limit state during its designated lifespan. This is particularly accomplished by ensuring that the structure is designed to prevent reaching:

1. The ultimate limit state dictates that the entire structure or its components must remain intact without experiencing collapse, overturning, or buckling when exposed to the specified design loads.

2. Serviceability limit states require that the structure remains functional and does not become unsuitable for use due to excessive deflection, cracking, or vibration. Additionally, the structure must exhibit durability, meaning it should not suffer significant deterioration or damage from substances that come into contact with it. The code places a strong emphasis on durability. In the case of reinforced concrete structures, it is standard practice to design for the ultimate limit state, verify serviceability, and implement all necessary measures to ensure durability.

I**. Ultimate Limit State** Values of partial safety factors for materials concerning the ultimate limit state.

The primary ultimate limit states and associated provisions are outlined as follows:

i Strength The design of the structure must accommodate the most extreme combination of loads it may encounter. The dimensions of the structural elements must be sufficient to withstand the axial loads, shear forces, and moments identified through analysis. The design process is based on ultimate loads and the material's design strengths, incorporating partial safety factors for both loads and material strengths. This approach allows for the independent assessment of uncertainties related to load estimations and material performance. The strength of the sections is evaluated using plastic analysis, which relies on the short-term design stress-strain curves for both concrete and reinforcing steel (Holland, 2023).

1. Standards for Safe Design - Limit States The criteria for ensuring safe design dictate that a structure must remain fit for its intended use throughout its expected lifespan, thereby avoiding the occurrence of any limit states. This objective is primarily achieved by designing the structure to avert the following conditions:

   2 The ultimate limit state mandates that the entire structure or its individual components must maintain their integrity, preventing collapse, overturning, or buckling when subjected to the designated design loads.

1. Serviceability limit states necessitate that the structure continues to function effectively and does not become unserviceable due to excessive deflection, cracking, or vibration. Furthermore, the structure must demonstrate durability, indicating that it should not experience significant deterioration or damage from materials it encounters. The code places considerable importance on durability. For reinforced concrete structures, it is customary to design for the ultimate limit state, assess serviceability, and implement all necessary measures to ensure durability.

I. Ultimate Limit State Values of partial safety factors for materials concerning the ultimate limit state. The principal ultimate limit states and their corresponding provisions are detailed as follows:

i Strength The structural design must account for the most severe combination of loads it may face. The dimensions of the structural components must be adequate to resist the axial loads, shear forces, and moments determined through analysis. The design methodology is predicated on ultimate loads and the design strengths of materials, incorporating partial safety factors for both loads and material strengths. This strategy facilitates an independent evaluation of uncertainties associated with load predictions and material performance. The strength of the sections is assessed using plastic analysis, which is based on the short-term design stress-strain curves for both concrete and reinforcing steel (Holland, 2023).

2. **ii. Stability** The regulations mandate that the structural configuration must guarantee both stability and resilience. The engineer tasked with overseeing overall stability is responsible for ensuring the coherence of the design alongside the specifics of various components. Achieving the overall stability of a structure involves the incorporation of shear walls, lift shafts, staircases, and rigid frame actions, or a combination of these

elements. The design must ensure that all loads—including dead, imposed, and wind loads—are effectively transmitted to the foundations (Makeham, 2019**).**

3. **iii. Robustness** The regulations stipulate that the design and planning must be structured in such a way that damage to a limited area or the failure of a single component does not precipitate the collapse of a substantial portion of the structure. This requirement necessitates that the design is resistant to progressive collapse. To reduce the risk of such failures, the following measures are advised: 1. The structure must be designed to withstand notional horizontal loads applied at the roof and floor levels. These loads should be equivalent to 1.5% of the characteristic dead weight of the structure, calculated between the mid-height of the storey below and either the mid-height of the storey above or the roof surface. The wind load should not be considered less than the notional horizontal load. 2. All structures must incorporate suitable measures to ensure robustness. II. Serviceability Limit States The structure must remain functional, avoiding excessive deflection, cracking, or vibration. Furthermore, it is crucial for the structure to demonstrate durability, indicating that it should not experience significant deterioration or damage from substances that may come into contact with it. In the design of reinforced concrete structures, the standard practice involves ensuring compliance with the ultimate limit state, verifying serviceability, and implementing all necessary measures to ensure durability. Consideration must be given to factors such as temperature, creep, shrinkage, and sway
4. **Deflection** refers to the deformation of a structure, which should not adversely affect its functionality or visual appeal. While it is possible to calculate deflections, it is often sufficient to utilize span-to-effective depth ratios to ensure compliance with established criteria (T.J. Mac Ginley and B.S. Choo). Furthermore, it is essential to manage cracking within acceptable thresholds through appropriate detailing practices. Although crack widths can be determined through calculations, following detailing guidelines related to bar spacing in tension zones is generally adequate for controlling cracking. In assessing a section for serviceability limit states, the analysis presumes a linear elastic relationship between the stresses in steel and concrete. This evaluation takes into account the stiffening influence of concrete in tension zones, along with considerations for creep and shrinkage (T.J. Mac Ginley and B.S. Choo, 1990). Ideally, the limit states concerning lateral deflection should consider situations where lateral sway may:

   - Limit the functionality of the structure

- Affect the performance of non-load-bearing components

- Alter the aesthetic quality of the structure

- Diminish occupant comfort Depending on the lateral-load-resisting system utilized, the maximum story drift typically occurs about one-third of the height in rigid frame structures, whereas in structures consisting solely of shear walls, it is observed at the uppermost story. Compliance with the drift limitations set forth by the applicable code of practice is imperative

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CHAPTER 3: MATERIALS AND METHODS

3.1 Introduction

This chapter outlines the methodologies and strategies used to execute this study. It details the research design, target population, sample size, sampling techniques, and research instruments, as well as their validity and reliability. Additionally, it covers the procedures for data collection, data management and analysis, ethical considerations, and the anticipated limitations of the study.

3.2. Selection of Methodology

The selection of an appropriate methodology significantly influences the success of a research endeavour. When a suitable research methodology is employed, obtaining favourable results becomes considerably more achievable. Essential information is required to ascertain various design loads and structural specifications, including columns, slabs, foundations, stairs, and beams. In this study, it is imperative to determine the soil's bearing capacity and compare it against the design load imposed by the building.

3.3. Methods and Approaches

The design strategy will encompass a comprehensive design process, emphasising a sustainable approach to hotel design. This will optimise the relationship between architectural excellence and its functional applications and expressions. Key considerations will include indoor climate factors such as ventilation, acoustics, structural analysis, and construction management, all of which will be integrated into the design parameters.

The Integrated Design Process consists of the following design parameters: - Problem Formulation: This stage involves articulating the project concept or identifying issues that require significant attention to develop effective solutions. - Analysis Phase: This phase entails a thorough examination of the site, considering elements such as the local context (genius loci), wind patterns, sunlight exposure, topography, functional requirements, indoor climate, and theoretical frameworks to gain a comprehensive understanding of the design parameters. - Sketching Phase: During this phase, architectural strategies are explored in relation to functional requirements, allowing for the testing of ideas and the evaluation of potential solutions from various perspectives that meet the design criteria established in the

Analysis phase. - Synthesis Phase: In this phase, the Building's form is conceptualised based on various computations and optimisations of the design parameters, aiming to achieve the design objectives outlined in the Analysis phase. - Presentation Phase: The completed project is presented in a report format, followed by an evaluation that includes digital presentations, models, and an oral defence of the report (Speroff,, 2013)

3.4. Description of the Area of Study

The selection of a plot is crucial for constructing a house. The site should be situated in a favourable location that offers community access while ensuring the convenience of services without being so close as to create disturbances or noise. Conventional transportation is significant not only for current needs but also for maintaining property value in the future, which is closely linked to transportation, shopping, and essential facilities. It is important to assess the roads' condition and identify any signs of potential future development, particularly in undeveloped areas. The site is located in the Nyakayenzi village, Rudashya cell of the Ndera sector, within the Gasabo district of Kigali city. The total area of the plot is 16 307 m².

Figure 3.1 Location of the plot to neighbouring plot

3.5. Research Design

This section delineates the study design for the structural development of a G+3 modern market building located in the Gasabo District, specifically within the Ndera Sector. The site selection process was governed by stringent criteria, including accessibility, evaluations of soil quality, drainage patterns, and the proximity to vital amenities. Comprehensive geotechnical investigations, soil testing, and topographical surveys were undertaken to thoroughly evaluate the selected site. Structural analysis was conducted using industry-standard software, which incorporated accurate load calculations for dead loads, live loads, wind loads, and seismic forces. Assessments of seismic hazards and wind loads were performed in accordance with local data and international standards. The design methodology involved careful selection of materials, justifying the choices of concrete grades, steel reinforcements, and masonry materials to meet project specifications. Structural components such as columns, beams, slabs, and shear walls were designed with precision, adhering to established engineering principles. The foundation design, a crucial element, was approached through detailed analysis that took into account soil-bearing capacities and structural loads. Throughout the design process, strict adherence to local building codes and regulations was maintained, underscoring the structural safety and integrity of the proposed Building. The use of computer-aided design tools facilitated simulations, allowing for the creation of a detailed and accurate structural model. Data collection involved thorough site surveys and laboratory testing, with subsequent analyses yielding essential inputs for the structural design. This chapter establishes a solid methodological framework, ensuring the structural viability and safety of the G+3 modern market building in the Gasabo District, Ndera Sector.

3.6. Source of Data Collection

The data collection process was conducted with great care to ensure that the information gathered was both comprehensive and precise for the structural design. This phase began with thorough site surveys, during which detailed topographical and geotechnical data were collected. Soil samples were systematically taken from various locations across the construction site for laboratory analysis, yielding critical insights into soil composition, bearing capacity, and other geotechnical characteristics. Architectural plans and blueprints for the G+3 apartment building were acquired and examined in detail to grasp the layout, dimensions, and architectural specifications. In-depth discussions were conducted with the architects and builders involved in the project to understand the aesthetic requirements and any distinctive design considerations. Additionally, local climate data, encompassing historical weather patterns and wind speed records pertinent to the Gasabo District, were sourced from appropriate meteorological agencies. This information was vital for accurately calculating wind loads, a key factor in the structural design process. Alongside site-specific data, an extensive literature review was performed to gather insights into best practices and innovative techniques in multi-story building design. Various scholarly articles, research papers, and textbooks were scrutinised to stay abreast of the latest advancements in structural engineering, ensuring that the design integrated contemporary methodologies and complied with industry standards and regulations. Furthermore, consultations were held with seasoned structural engineers and industry professionals. These discussions provided valuable qualitative data, offering practical insights and expert perspectives on the challenges and considerations unique to constructing multi-story buildings in the Gasabo District. The data amassed during this phase served as the cornerstone for the structural design, reflecting a rigorous commitment to detail and accuracy.

.3.6.1 Primary Data

For this study, primary data, defined as original information gathered directly from the population by the researcher was utilised. The data collection instrument employed was a questionnaire, which was administered in person by the researcher and their assistants. The questionnaire primarily consisted of structured (closed-ended) questions to facilitate ease of administration and subsequent analysis. Data was collected in the field using the following methods:

- Conducting direct interviews and inquiries with homeowners.

- Performing site visits to make on-site observations and assess existing facilities.

- Capturing photographs of the facilities visited and creating diagrams for illustrative purposes. **3.6.2. Secondary Data**

Secondary data refers to information obtained from previously conducted research relevant to the study, (Riley, 2023). In this research, secondary data was sourced from books, reports,

Table 3.1 : Bearing Capacity reference data at Gasogi

UNIVERSITY OF RWANDA - COLLEGE OF SCIENCE AND TECHNOLOGY (Huye Campus)
SCHOOL OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT
LABORATORY OF GEOTECHNICS

PROJECT: IMPROVEMENT OF SUBSTATION & DISTRIBUTION NETWORK - PHASE III

SUB PROJECT: 15 KV Distribution line Gasogi Substation - Masaka Hospital

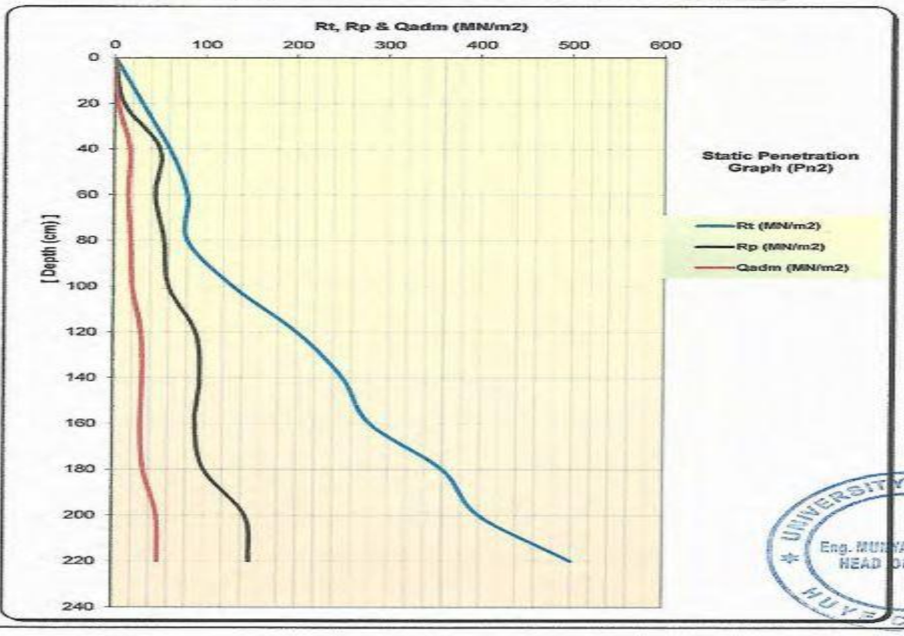
Client: PITRAD IBAMBA LTD.

Operated by: Eng. Venerand GWIZA
Verified by: Eng. Vivien MUNYABURANGA (MSc)
Date: July, 2017

Penetration Test N°AP 12

Depth (cm)	Rt (MN/m2)	Rp (MN/m2)	Qadm (MN/m2)	Qadm (kg/cm2)
0	0	0	0.00	0.00
20	30	10	3.33	33.99
40	60	50	16.67	169.95
60	80	45	15.00	152.96
80	80	55	18.33	186.95
100	130	60	20.00	203.94
120	200	90	30.00	305.92
140	250	95	31.67	322.91
160	280	90	30.00	305.92
180	360	100	33.33	339.91
200	400	145	48.33	492.86
220	500	150	50.00	509.86
240				

180	360	100	33.33	339.91
200	400	145	48.33	492.86
220	500	150	50.00	509.86
240				



journals, electronic publications, maps, Google Maps, and ortho-photos. This information was derived from existing literature in the field of study. The sources included:

- Textbooks pertinent to the research topic.
- Previous theses and projects.
- Sessional papers.
- Newspapers and journals.
- Internet resources for additional information and data collection.
- Internationally recognised research encyclopedias.

3.7. Data Collection Instruments

The following instruments were employed to collect vital information for the research:

1. Site Survey Forms: Structured forms were created to document comprehensive site observations, encompassing topographical features, existing structures, soil conditions, drainage patterns, and surrounding environmental factors. These forms enabled systematic data collection during site visits.

2. Soil Testing Protocols: A specific set of protocols was established for the collection of soil samples and their subsequent laboratory testing. These protocols detailed the procedures for sample collection. Soil samples were obtained from various depths, locations, and soil types within the construction site. Standard laboratory analyses, including assessments of soil composition, compaction, and shear strength, were performed on these samples.

3. Architectural plan evaluation checklist

A checklist was created to systematically evaluate the architectural plans and blueprints for the G+3 Modern market building. This tool ensured that essential architectural specifications, such as dimensions, layouts, and aesthetic features, were meticulously documented and taken into account during the structural design phase.

4. Climate data gathering instruments:

Instruments were developed to gather climate-related data, encompassing historical weather trends, temperature variations, and wind speed records pertinent to the Gasabo District. These instruments enabled the systematic collection of meteorological data, which was vital for accurately estimating wind loads in the structural design calculations.

Instruments such as anemometers, barometers, and hygrometers have played crucial roles in the systematic collection of meteorological data. Anemometers measure wind speed and direction, providing essential information for estimating wind loads on structures. Barometers help in understanding atmospheric pressure changes, which can also influence wind patterns, while hygrometers measure humidity levels, contributing to a comprehensive understanding of environmental conditions.

The Softwares

Data Acquisition Systems: Specialized software interfaces with sensors and instruments (like anemometers, thermometers, and rain gauges) to automate data collection and ensure accurate readings.

Data Processing and Analysis: Software packages can process large volumes of data collected from various instruments, allowing for advanced statistical analysis, trend identification, and forecasting.

Visualization Tools: Programs like GIS (Geographic Information Systems) and data visualization software help map and graph climate data, making it easier to interpret and communicate findings.

Remote Sensing: Software is crucial in processing satellite data and other remote sensing information, providing insights into larger climatic patterns and changes over time.

Climate Modeling: Advanced simulation software is used to create climate models that predict future conditions based on historical data, helping in planning and design efforts.

Database Management: Software solutions manage and store large datasets, enabling easy access and retrieval for analysis or reporting purposes.

Mobile Applications: Some software applications allow for real-time data collection and monitoring through mobile devices, making it easier for researchers and engineers to gather data in the field.

5. Literature review framework

A structured framework was established to organise and analyse literature concerning multi-story building designs from scholarly articles, research papers, and textbooks. This framework facilitated the categorisation of pertinent studies, allowing for a thorough literature review and the identification of best practices and innovative techniques in structural engineering.

6. Expert interview protocols:

Semi-structured interview protocols were created to engage with seasoned structural engineers and professionals in the field. These protocols included a series of open-ended questions designed to collect qualitative data on challenges, considerations, and expert insights specific to the construction of multi-story buildings in the Gasabo District. These data collection instruments were meticulously crafted to ensure consistency, accuracy, and relevance in gathering information critical to the research objectives of the dissertation. The use of a combination of structured forms, protocols, checklists, and interview guides enabled a comprehensive and thorough exploration of the subject matter.

3.8. Architectural Drawing of the Proposed Structure

Architectural drawings, also referred to as architect's drawings, are technical representations of a building designed to meet the expectations of clients and serve as a means of conveying ideas, concepts, and intricate details. These drawings require a blend of professional expertise in both contemporary and traditional architectural techniques. To fulfil client requirements, architects must conduct preliminary studies and research while adhering to the constraints and recommendations provided by their clients.

3.8.1. Overview of the Designed Structure

Given that the Building is intended to function as a hotel, it is anticipated that there will be significant foot traffic. Consequently, the plot area must be expansive to ensure adequate oxygen supply. Based on these considerations, we propose a plot area of 423.15 m^2.

3.8.2. Building Coverage

Building coverage refers to the portion of a site occupied by the Building or any part thereof, including overhanging or cantilevered sections. This encompasses any elements such as eaves or spouting that extend more than one meter horizontally from the exterior walls. Our proposed building coverage area is 423.15 m².

3.8.3. Gross Area

The gross area is defined as the total of all areas across all floors of a building, measured within the outer faces of its exterior walls, including all vertical penetrations. The gross area for this Building is calculated to be 1269.45 m². 3.6.4. Landscape Coverage

/Green Area/Paved Area Landscape coverage is defined as all ground areas surrounding the main Building and any accessory structures that do not include garden spaces, driveways, parking lots, sidewalks, or patios. Landscape requirements pertain solely to surface parking. According to our drawings, the landscape coverage is 279 m².

3.8.4. Floor Area Ratio

The floor area ratio (FAR) represents the relationship between the total usable floor area of a building and the total area of the plot on which it is situated. The FAR is calculated using a straightforward formula based on the total covered area.

3.8.5. Materials

The primary materials utilised in the construction of this Building include reinforced concrete and steel tubes for fencing, with gates constructed from both steel and wood where necessary.

3.7. Software

Regarding engineering software, its significance is well recognised, and recent advancements in software development have greatly enhanced various civil engineering fields. Such tools enable engineers to conduct a wide range of complex calculations, modelling, drafting, design practices, and numerous analytical processes essential for civil engineering infrastructure. For architectural drawings, ArchiCAD 23 was employed, while Lumion 12 was utilised for rendering tasks. Microsoft Word was used for documentation and compiling the bill of quantities. Additionally, spreadsheets based on BS110.1997 were employed for structural analysis, facilitating the design of all structural components, including slabs, beams, columns, stairs, and foundations, ensuring precise calculations and accurate outcomes.

3 3 4 Data Analysis

Qualitative Analysis:

Transcribe and code interview data to identify themes and patterns.

Use thematic analysis to categorise responses related to customer preferences, vendor challenges, and market trends.

3.8 Design of Slab

Slab is horizontal,flat structural element that provide as a cover or floor of the building slab support different load such as its self weight and imposed load its design in two methods.

One -Way slab and two-way slab (Hayes, 2018)

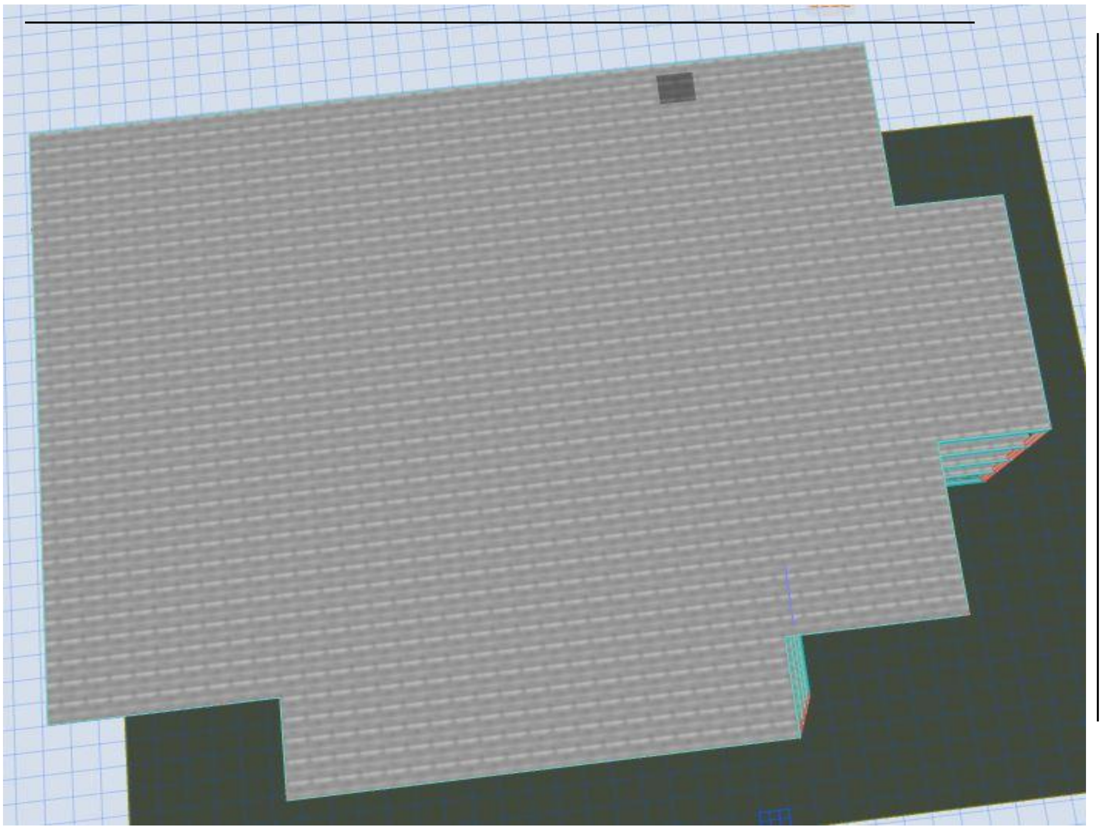


Figure 3.2 Structural slab

Condition

$\frac{LY}{LX} > 2$ The slab is a one-way slab

$\frac{LY}{LX} \leq 2$ The Slab is a two-way Slab

Loadings

F= (1.4GK + 1.6 QK)

MRC= 0.156 $fcubd^2$

$$d = h - cover - \frac{Ø\, main\ bar}{2}$$

$$K = \frac{M}{fcubd2}$$

$$AS = \frac{M}{0.95fyZ}$$

3.9 Design of beam

A beam is a horizontal structural element that is designed to resist loads applied perpendicular to its longitudinal axis. Beams are critical components in structures like buildings, bridges, and other infrastructure where they serve to support vertical loads (such as the weight of floors, roofs, or vehicles) and transfer these loads to vertical supports such as columns or walls and also directly in foundation untily in hard soil.

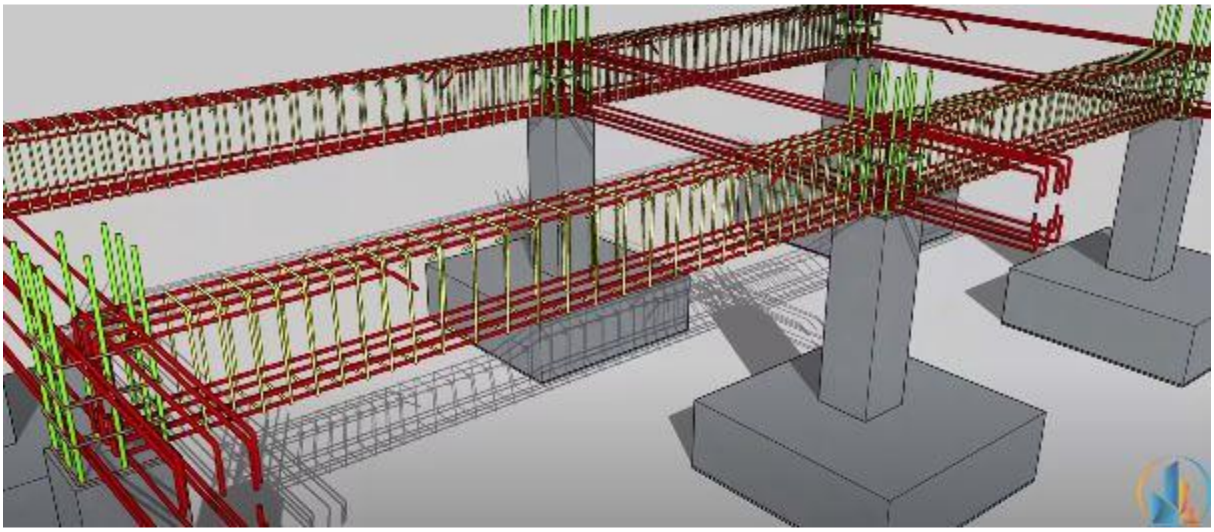


Figure 3.3 Structural reinforcement of Beam

If Mu < M.R.C., the Neutral axis is located in the flange, then the beam will be designed as a rectangular beam.

If Mu > M.R.C., the neutral axis is located on the web, then the beam will be designed as a flanged beam.

MRC= 0.45 fcubhf (d-hf)

Moment of resistance of steel

MRS= 0.736dfyAS

Moment of Resistance of Concrete

MRC = 0.156fcubd^2

For equilibrium

MRS = MRC

0.736 dfyAS = 0.156fcubd^2

$$AS = 0.212\frac{fcubd}{fy}$$

Mu < M.R.C. No Compression bars required

Mu > M.R.C. Compression bars required

MU=ultimate moment / Maximum moment

MRC= Moment of resistance of concrete

$$AS = \frac{MRC}{0.95fyz}$$

Double reinforced Beam

$$AS = \frac{0.214fcubd}{fy}$$

$$AS = \frac{M}{0.95fyZ}$$

Tension Reinforcement

$$AS = \frac{\mathrm{M + 0.1\ cubed(0.45d - ht)}}{\mathrm{0.95fy(d - ht)}}$$

Tension Reinforcement and Compression Reinforcement

$$AS = \frac{\mathrm{M} - \mathrm{MRC}}{0.95\mathrm{fy}(\mathrm{d} - \mathrm{d})}$$

Determine shear force

$$vc^{x} = \frac{0.79 * \left(\frac{100ASprov}{bd}\right) 1/3 + (\frac{400}{d}^{\frac{1}{4}}) + (\frac{fcu^{1/3}}{25})}{1.25}$$

$$\frac{(100ASprov)^{1/3}}{bd} > 1$$

$$\frac{(400)^{1/4}}{d} > 1$$

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

Shear Stress = V =w=$\frac{V}{bd}$

Deflection of Beam

Modification factor

$$MF = 0.55 + \frac{477 - fs}{120(0.9 + \frac{M}{bd2})} \leq 2$$

$$Fs = \frac{\overline{\frac{2}{3fyxASreq}}}{ASprov} X \frac{1}{\mathrm{db}}$$

3.8 Design of column

A column is a vertical structural element that primarily supports compressive loads. Columns are fundamental components in buildings, bridges, and other structures where they transfer loads from the superstructure (such as floors or beams) to the foundation. They play a crucial role in providing vertical support and maintaining the overall stability of the structure.

Code classifies columns into two types.

-Short column is when lex/h and ley/h is less than 15 for braced column and less than 10 for

Embraced column

Lex= effective height with respect to the major axis

Ley= effective with respect to minor axis

In order to control cracking in column b should be dependent to

3.9 Design of short columns

Design of short column subjected to axial load

N=0.45 fcuAC +0.95 fyASC

h=h-cover-Ømainbar/2–Ølinks

CHAPTER 4 RESULT AND DISCUSSION

4.1. Introduction

Give a summary of the Rwandan markets. Describe recent advancements in Rwanda's economy, such as growing industries,such as morden market building to design different structural of the buiding , technological progress, and shifts in consumer habits. Clearly state the objectives of your project. For instance, you could seek to assess how digital platforms are influencing consumer behaviour in Rwanda, evaluate the expansion of e-commerce, or examine the efficacy of contemporary retail tactics.

This chapter is concerned with load calculation drawings, specifications and cost estimation of the whole project

4 2 Calculation

4 2 1 General loading condition

In contemporary architectural and structural design, specifically for the commercial sector, it is important to take into account different load conditions to guarantee safety, stability, and functionality.

In areas with active markets, the general road conditions can vary significantly depending on several factors, including the level of development, local maintenance practices, and the volume of traffic. Here are some common stages or conditions you might encounter:

Well-Maintained Roads**:** In many thriving market areas, roads are well-maintained to handle heavy traffic and ensure smooth access for vendors, shoppers, and delivery vehicles. These roads are often paved, with regular upkeep to prevent potholes and other issues.

Under Construction: In developing markets, you might find roads that are under construction or undergoing upgrades. This can include resurfacing, widening, or other improvements to accommodate increasing traffic and enhance safety.

Traffic Congestion**:** Active market areas often experience high traffic volumes, which can lead to congestion and wear on the road surfaces. This is particularly true during peak hours when vendors are setting up or when large numbers of people are shopping.

Temporary Detours and Blockages**:** During construction or market events, temporary detours or road blockages may be in place. This can affect the general condition of the roads and require adjustments to traffic flow.

General Road Condition

Table 4.1 General Road Condition

Types	Description
Market building	
Roof impose: 1.5 N/ m^2 Roof load: 0.5 KN / m^2 Floor-imposed:8 K.N./m^2 Finishes: 2 K.N. / m^2 Stairs – imposed: 4 K.N./m^2	General loading condition
Severe (external) and mild (internal)	
Concrete: grade C 35 Mix ratio : 1: 0.75:1.25 (cement, sand .coaser aggregate) Reinforcement -Main steel fy = 460 N/ mm ^{2} - Stirrup fy = 250 N /mm2	Material data
Unit weight of reinforced concrete:24 K.N./m^3 Unit weight of masonry wall = 18 KN / m^3	
For dead load: 1.4 For live load: 1.6	Partial factors of safety for loading
Clay - gravel allowable bearing = 550 KN /m^3 ^{or} KPa	Subsoil condition
Fire resistance: 1 hour for all elements and cover = 22mm for slab and beam Cover = 25mm for the column and foundation Self- the weight of the concrete = 24 K.N./mm^2	

Slab element

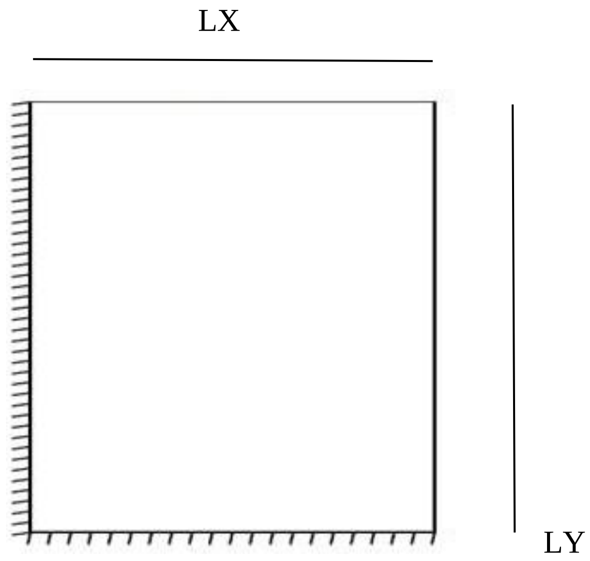


Figure 4.1 Two adjacent edge discontinuous critical panel.

Pre-design

Ascertain the necessary load

Determine the dead load by weighing the slab in its whole, including the materials (concrete, reinforcements).
Live Load: Evaluate extra loads brought on by people, furnishings, appliances, and dynamic forces.
Environmental Loads: Take wind, snow, and seismic activity into account.

Select Slab Type

For rectangular slabs supported by beams on two opposing sides, use a one-way slab. Two-Way Slab: A slab that distributes loads in two directions and is supported on all four sides.
No beams are needed because the slab supports the columns directly, creating more room for open areas.

Waffle Slab: A two-way slab that lowers weight and increases strength with a grid pattern. Selection of Materials

Select appropriate materials considering cost, durability, and strength. Typical options consist of:

Reinforced concrete provides durability and strength.

Precast Concrete: Facilitates speedier construction and quality control

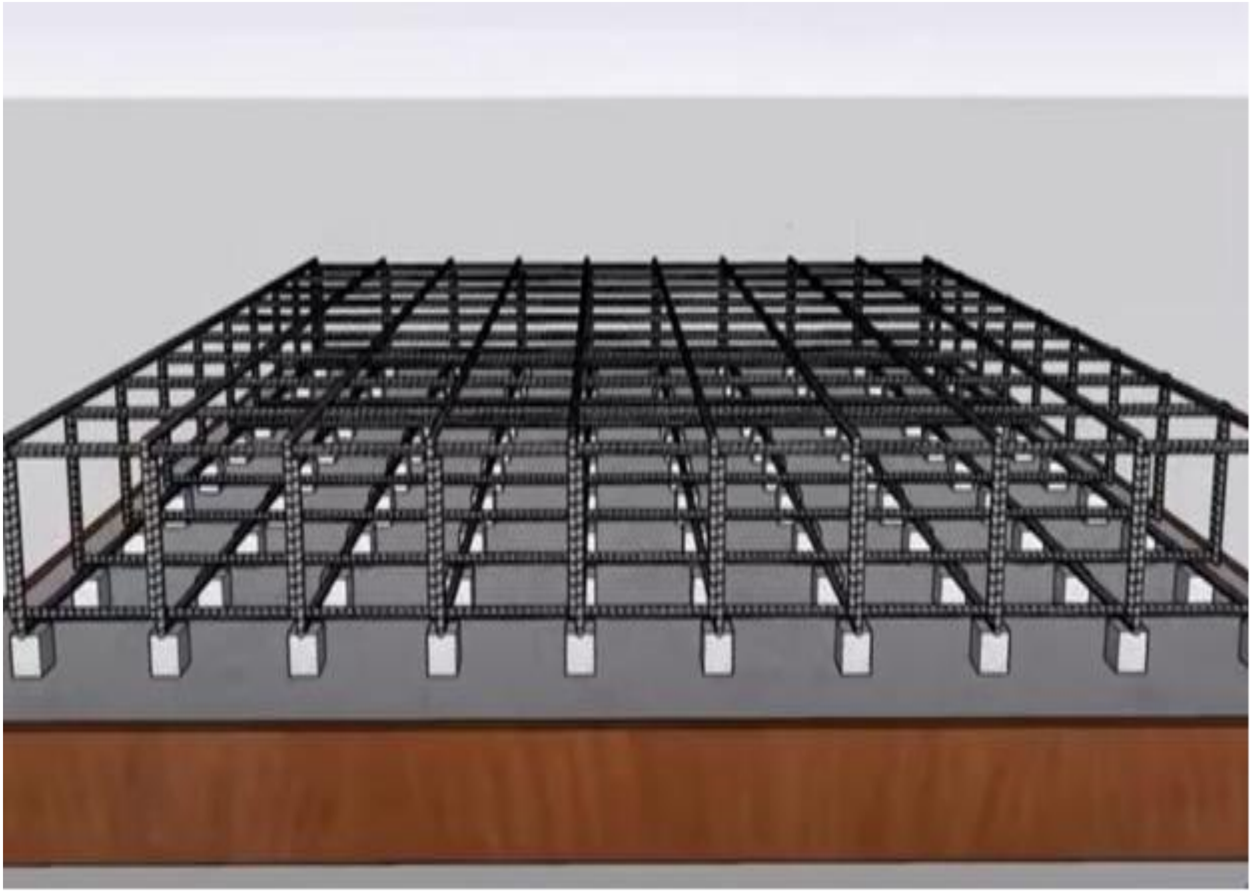


Figure 4.2 Reinforcement bar of slab

4 2 2 Design of slab

To design the slab, we consider the following data: two-way slab and one-way slab.

$$\frac{LY}{LX} \leq 2$$

$$\frac{52.1}{42.9} = 1.2 \ \leq 2$$

This is a way slab from the calculation

The thinking of slab is between

$\frac{LX}{40}$ and

$\frac{Lx}{25}$

$$Hf = \frac{429}{40} = 10$$

$$Hf = \frac{429}{25} = 17$$

We have to consider that the thickness of slab (ht)= 15 cm

The type of slab is the two-way slab

$$\frac{LY}{LX} \leq 2$$

$$\frac{52.1}{42.9} = 1.2 \ \leq 2$$

Loads on slab

We consider that breadth of equal to 1m

Live consideration equals 5 KN/m

Unit weight of concrete=24 KN/m^3

Unit weight of masonry=19 KN/m^3

Unit area of finishes= 20 KN/m^2

Self-weight of slab= 1.4x0.15x24KN/m3x 1=5.04KN/m

Finishes=1.4x1x20=28 KN/m^2

Total dead Loads= 5.04 KN/m^2 +28KN/m^2 = 33.04 KN/m^2

Live Load = 1.6x5x1=8KN/m^2

Total design Loads=33.04KN/m^2+8KN/m^2 = 41.04KN/m^2

Moments calculation

MSx= BSx X n X (lx)^2 =

MSy= BSx X n X (ly)^2 =

Short side :MSx$^-$ = 0.042x 41.04x(4.2)^2 =0.042x41.04x17.64= 30.40KN/m^2 (sagging moment)

MSx+ =0.032x41.04x(4.2)^2 = 0.032x41.04x17.64=23.16 KN/m^2 (Hagging moment)

Long side : MSy -=0.032 x 41.04x(5.2)^2 =0.032x41.04x27.04= 35.51 KN/m^2

MSy+=0.024x41.04x(5.2)^2 = 26.63 KN/m

MRC=0.156fcubd^2

d=h-cover-Ømain bar/2

Let us assume Ø main bar = 16 mm

D=150mm-25mm-16mm /2=133mm

MRC=0.156 X 30 X1000 X133^2 =82784520 Nmm =82.78 KN/mm

M< M.R.C. No compression bar required

$$K = \frac{M}{fcubd2}$$

$$K = \frac{35.51}{30X1000X133} = 0{,}0066$$

K<Kbal 0.0066< 0.0156 no compression

Z=d[0.5+$\sqrt{0.25 - K)}$ > 0.9d

Z=133(0.5+$\sqrt{0.25} - 0.35$

127.68>119.7

Let us take Z= 119.7mm

$$AS = \frac{M}{0.95fyZ}$$

$$AS = \frac{35.51X1000000}{0.95X460X119.7} = 678.85 \text{ mm}^2$$

$$AS = \frac{23.16X\ 1000000}{0.95X460X119.7} = 442.75 \text{ mm}^2$$

The number of steel required is 4T12@50

4 2 3 Beam element

Introduction

A beam element is a key part of structural engineering and mechanics, utilised for modelling and analysing structures that mainly undergo bending. Here is a basic overview of beam components:

A beam element is a fundamental component in structural engineering and mechanics used to model and analyse structures that primarily experience bending. Here's a general introduction to beam elements:

Definition:

Beam Element: A basic structural component created to bear loads and withstand bending moments, shear forces, and axial forces. Beam elements are employed to portray the characteristics of beams in a structural analysis simulation.

A simplified structural member that is designed to support loads and resist bending moments, shear forces, and axial forces. Beam elements are used to represent the behaviour of beams in a structural analysis model.

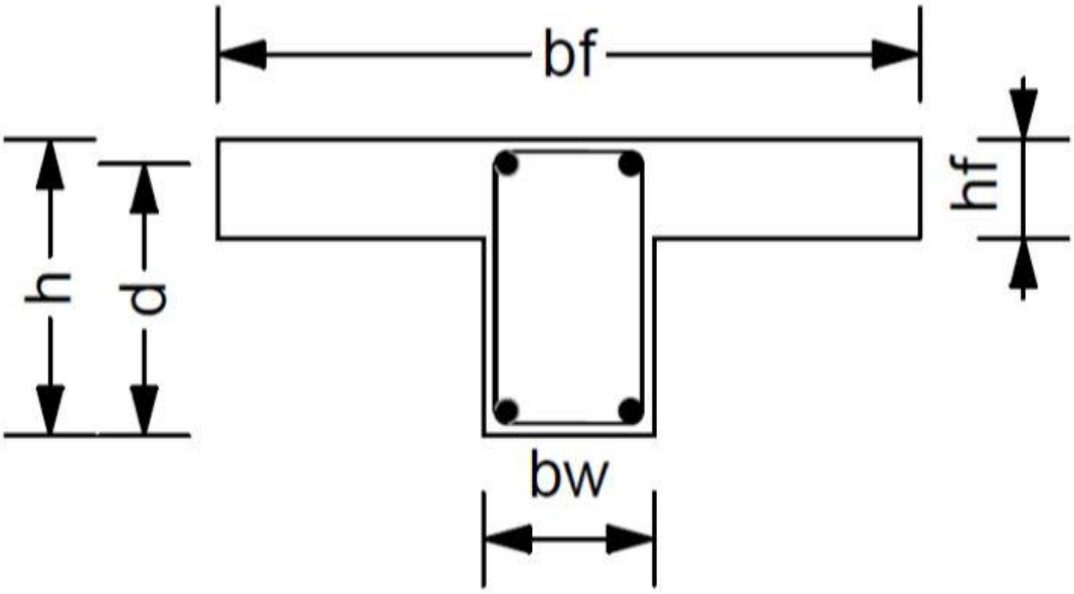


Figure 4.3 Flanged T-beam for beam

Load from beam=1.4xbreadth of beam x thickness of beam x beam length x unit weight of concrete

Breadth=300mm

Thinkness=80cm

The steel characteristic strength is 460 N/mm^2

Span=12m

Fy = 460 N $/m^2$

Fcu= 30 N $/m^2$

Load from beam=1.4 x 0.3 x0.8 x 18.82 x24=151.76 KN/m

For Moment Is equal

M=W $L^2/8$=151.76 X $12^2/8$= 2731.68KN/m^2

MRC= 0.45 fcubfhf (d- $\frac{hf}{2}$)

d= h- cover-Ø $\frac{main\ bar}{2}$ - Ø stirrup

Let us assume Ømain bar =25 mm

Ø stirrup = 8 mm

Cover= 25 mm

d= 350mm-25mm- $\frac{25}{2}$ mm -8mm = 304.5 mm

bf=bw+ $\frac{Lz}{5}$ for T beams

bf= bw + $\frac{LZ}{10}$ for L beam

for continuous beam LZ =0.7 x effective span

LZ= 0.7 X 12= 8.4 m= 8400 mm

Bf= 300mm +$\frac{8400}{5}$ = 1740 mm

M.R.C. = 0.45 X 30 X 1740 X 300 (304.5 - $\frac{300}{2}$)= 1088761500 N/mm =1088.7615 KN/m

M < M$^{.R.C.}$ The neutral axis is located in the flange beam and will be designed as a rectangular beam

MRC = 0.156 fcubd^2

MRC= 0.156 X 30 X 1740 X (304.5) ^{2} = 755039539.8 N/mm =755.03 KN/m

M < M.R.C. There is no compression bar required, so the compression bar is required because M > than M.R.C.

M > M.R.C. is greater equal 2731.68 >755.03

AS=$\frac{M}{0.95\ fy\ Z}$ (Area of steel)

$Z = d(\ 0.5 + \sqrt{0.25} - \frac{K}{0.9}\ ) > 0.95$ d

$K = \frac{M}{bd\ 2\ fcu} = \frac{2731.68}{1740\ x\ 304.5\ x\ 304.5\ x\ 30} = \frac{2731.68}{4839997050}$ =0,005<0.156

$Z = 304.5\ (\ 0.5 + \sqrt{0.25 - \frac{0.015}{0.9}}$ > 0.95 d

Z = 299.35 > 0.95 d

Z= 302.8 > 289.27

$AS = \frac{2731680000}{0.95\ x\ 460\ x\ 302.8} = 2064.9\ mm^2$

The number of steel required is 7T20@50

Double reinforced Beam

$$AS = \frac{0.214 fcubd}{fy}$$

$AS = \frac{0.214\ X\ 30\ X1740X304.5}{460}$ = 7394.5 mm ^{2}

The number of steel required is 6T40@175

4.2.4 Design of column

A Column is a vertical structural element that supports loads from the roof or floor and transmits them to the foundation

The short column is when $\frac{Lex}{h}$ and $\frac{Ley}{h}$ is less than 15 for the braced column and less than 10 for the embraced column

Lex = effective height with respect to the major axis

Ley= effective height with respect to minor axis

h = width of column

b= breadth of column

–Alex = $\frac{3.8}{0.3}$ = 12.6 < 15 our is short column

4 2 5 column designing

Typical column: short column load

Column size =300mm x300mm

Dead load and steel reinforcement calculation ground floor

Self–weight of column =1.4 x width of column x breadth of column x height of column x unit w

Weight of concrete

= 1.4 x 0.3 x0.3 x3.5 x24 = 10.58 KN/

Load from beam = 1.4 x breadth of beam x thickness of beam x beam length x unit weight of

Concrete

=1.4 x 0.3 x 0.8 x18.82 x24 = 151.76 KN/m^2

Load from slab = Design load of slab x influence are

= 41.04 x 81.94 = 3362.81 KN

Total dead load = 10.58 KN+151.76 +3362.8= 3525.14 KN

Live load calculation

Live load =18.82 KN x 1 KN /m2=18.82 KN

The ultimate design load = 1.4 GK +1.6QK

Design load (N)=1.4 X 3525.14 +1.6 X 1.5 = 4965.302 KN

Nu = 0.4 fcu AC + 0.75 fy AS

4965300N = 0.4X30X300X300 + 0.75X460XAS

AS = $\frac{4965300N - 0.4X30X300X300}{0.75X460}$ = 11261.7mm [2olumnolumn]

The number of steel required is 9T40@100

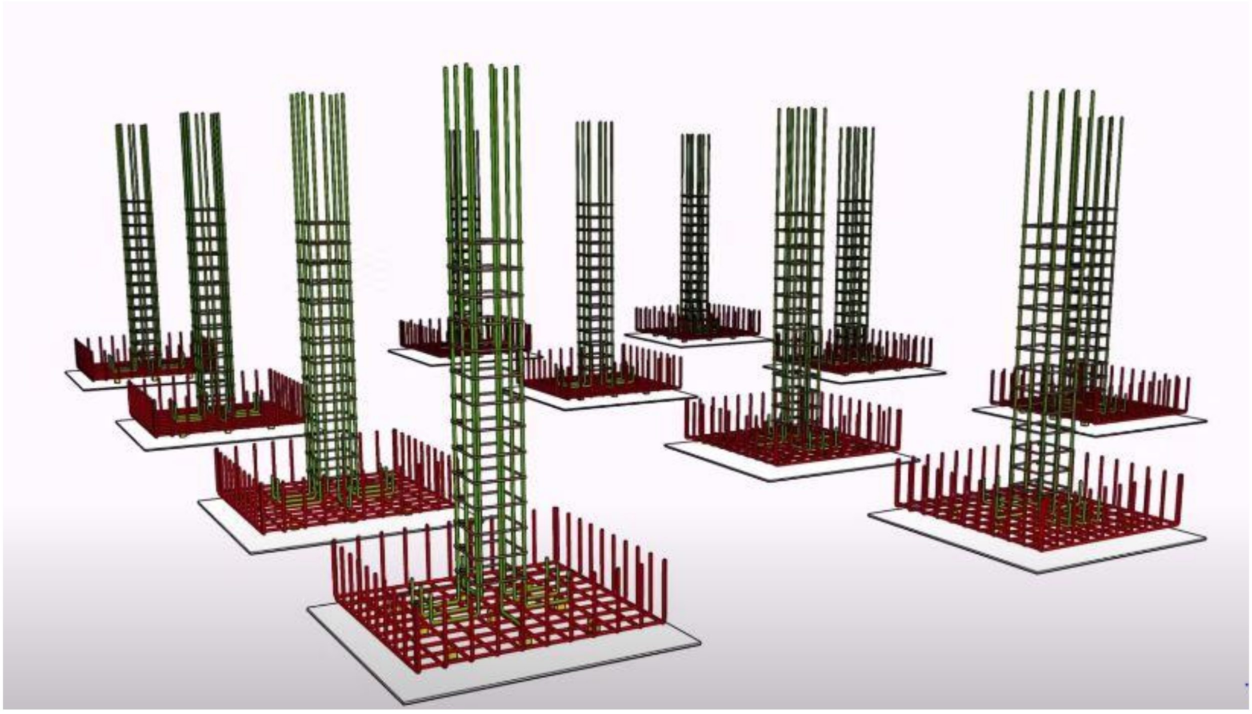


Figure 4.4 Column and Footing reinforcement bars

2.2.5 Design foundation

The foundation is the lowest point of the building, which supports loads from the upper point and distributes them to the soil. Loads should be distributed evenly at the same, externally in order to avoid failure of the Building (unequal settlement of Building)

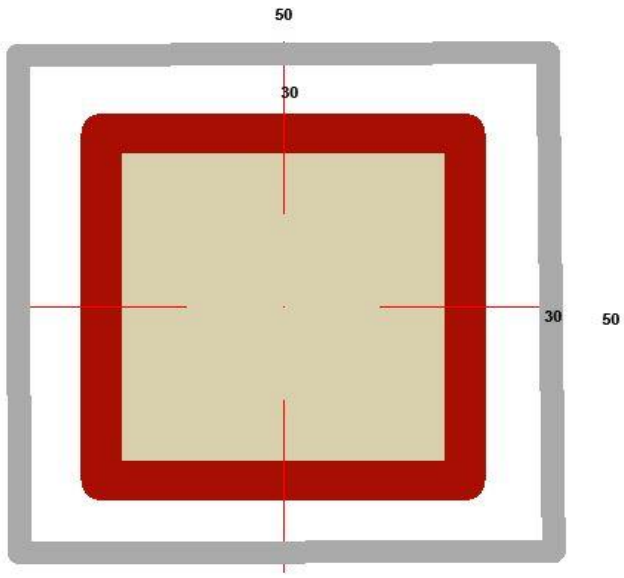


Figure 4.5 Foundation

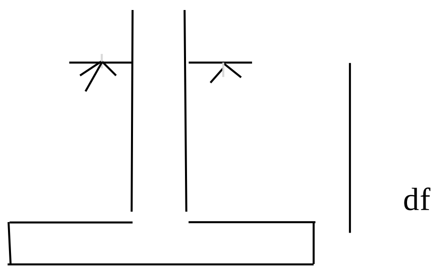
Classification of Foundation

-Shallow foundation is the foundation whereby

$\frac{df}{B} \leq 2.0$ Where

df= depth of foundation

B Base of foundation



lFigure 4.6 foundation structural

Deef foundation is the foundation whereby $\frac{df}{B} > 2$

Load calculation

$\frac{df}{B} = \frac{250\ cm}{50cm} = 5\ cm\ > 2$ There is a deep foundation

Load on the footing

= 1.0 GK + 1 QK + W =Service load of Column +w

Let us say w=10% (1.0 Gk + 1.0 Qk)

Load of column = 4965.3 KN

W = $\frac{4965.3\ KN\ X\ 10}{100} = 496.53\ KN$

Load on footing =4965.3 KN + 496.53 KN = 5461.83 KN

Area of footing = $\frac{Load\ on\ footing}{bearing\ capacity} =$

Bearing capacity = 550 KN /m^2

Area of footing$= \frac{5461.63\ KN}{400\ KN\ /m2} =$ 13.65 m^2

Square Footing = $\sqrt{13.65} =$ 3.6 m x 3.6 m

Design Stress =$\frac{Design\ \ load\ (Nd)}{Area\ of\ footing}$

If the design Stress $< B$earing capacity of the foundation is Safe

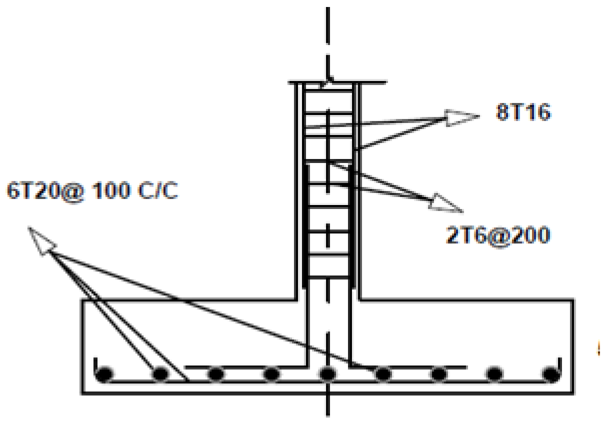


Figure 4.7 Reinforcement layout in foundation

f design stress > Bearing capacity, the foundation is unsafe

Consider rectangular footing. Let us assume one side equals 2.8 m. The demission equal $\frac{9.93}{2.8}$ =3.5 m equal = 2.8 m x 3.5 m

Consider design load =4200 KN

Design stress=$\frac{4200}{3.6\ X\ 3.6}$ = 307.69 KN / m^2

Design Stress < Bearing capacity ,307.69 $KN/m2$ < 400 KN /m^2 the foundation is safe

4 2 6 Design of Stairs

The stair is a structural element that allows movement from one floor to another floor.

Height to Landing = 1.75m

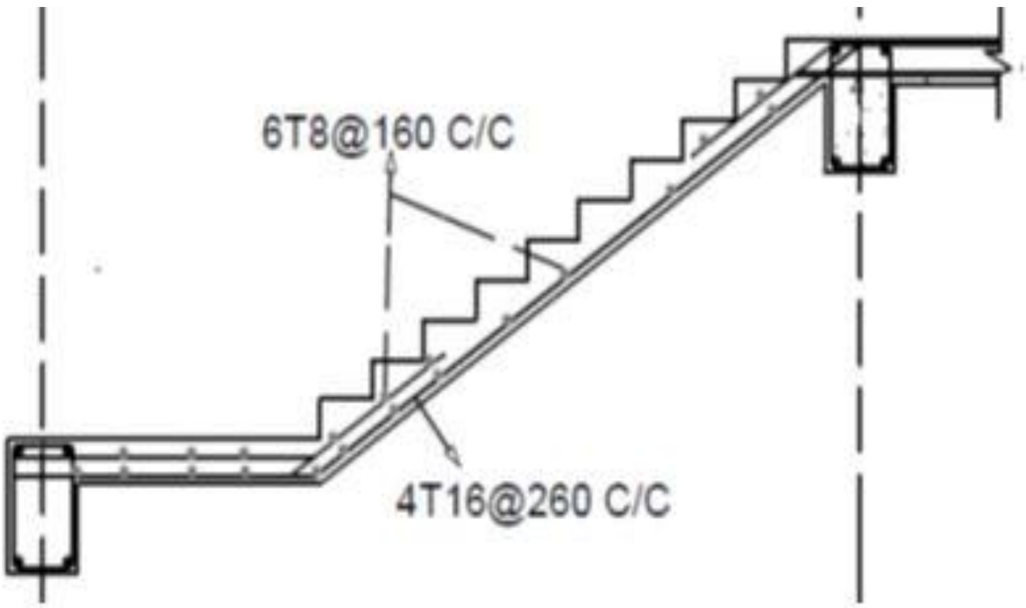


Figure 4.8 : Reinforcement layout of stair slab

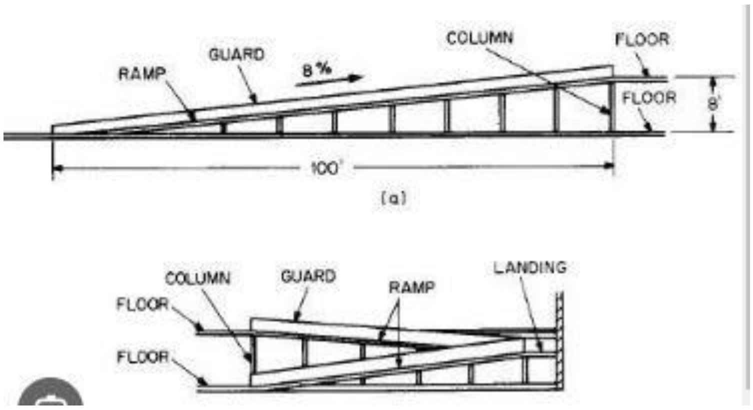


Figure 4 .9 : Ramp design Section

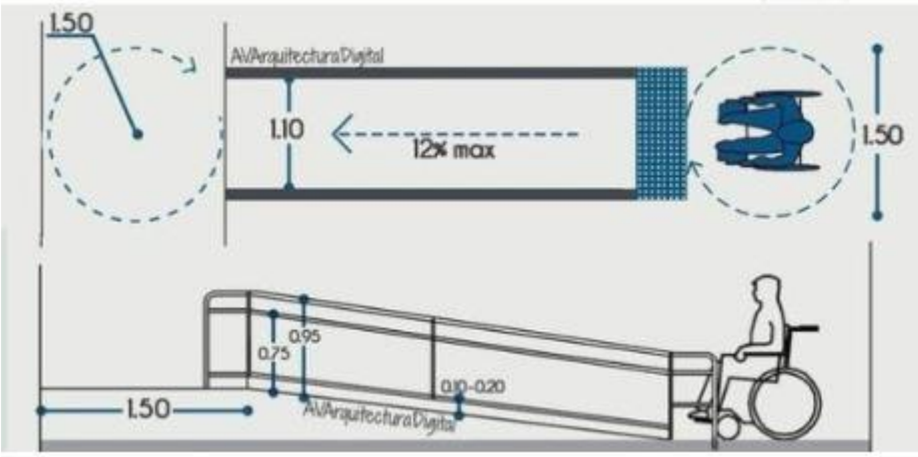


Figure 4.10 : Ramp architectural Design

Height of floor to floor = 3.8 m

Width of beam /width of column = 30cm

Number of going = 10 goings

Number of riser = 10 + 1 =11 risers

Size of riser = $\frac{1750\ mm}{11}$ = 159 mm = 160 mm

Let us take

2R + G = 625 mm

625mm – 2 x 160 mm = G

G = 305 mm

Effective horizontal length

La + 0.5 (Lb1 + Lb2)

Where La = is the length of the stair, including the landing

b1 and < b2 = width of support/width of beam

4m + 0.5 (0.3 m + 0.3 m)

=4.3 m

Length of going of flight number of going x size of going = 10x305mm = 3050mm

Centre to centre length of going of flight =3050 mm + 0.5 (300mm+300mm) = 3350 mm

Length of flight = $\sqrt{(riser\ of\ flight)2 + length\ of\ going\ of\ flight)}^2$

Length of flight = $\sqrt{(\ 1750\ mm) + (\ 3350\ mm)}^2$

=3062500 +11222500 = 14285000 =3779.5 mm

Slop = tan $^{-1}$ □ = $\frac{Riser\ of\ flight}{Horizontal\ distance}$

$\frac{1750}{3350} =$

Dead load calculation

Seif – weight = 1.4xthinkness stair slab x length of flight x width of flight x unit weight of concrete

Self-weight=1.4 x0.2mx3.779.5mx 1.9x25 KN/m^3 = 50.14 KN

-Imposed load = 1.6xlenght of flight width imposed load from the table

Imposed load = 1.6 x 3.779 m x 1.9 m x 3KN/m^3 = 34.46 KN

Total Design load on Stair= Design dead load + Design imposed load =

= 50.43 KN + 34.96 KN = 84.89 KN

Landing

Self-weight of landing=1.4x width of landing length of landing x thickness of landing unit of concrete x0.5

Self-weight of landing = 1.4 x 1.95 m x1.9mx 0.16 m x25 KN/m^3 x0.5= 10.37 KN

Imposed load = 1.6 x 1.95m x1.9m x3 KN/m^3 x 0.5 = 8.89 KN

Total Design load = 10.37 KN+ 8.89 KN = 19.26 KN

M= WL^2 / 8

M= $\frac{19.26\ X\ 4.3X4.3}{8}$ = 44.5 KN

Let find K =$\frac{M}{fcubdxd} = \frac{44.5}{30x1000x120x120} = 0.014 < 0.156$

Z= 115 (0.5 +$\sqrt{0.25 - \frac{0.014}{0.9}}$ = 113.5 mm

As =$\frac{M}{0.95fyz}$`

AS=$\frac{44500000}{0.95X460X113.5} = 897.1$ mm^2

The number of steel bars requires 2T25@125

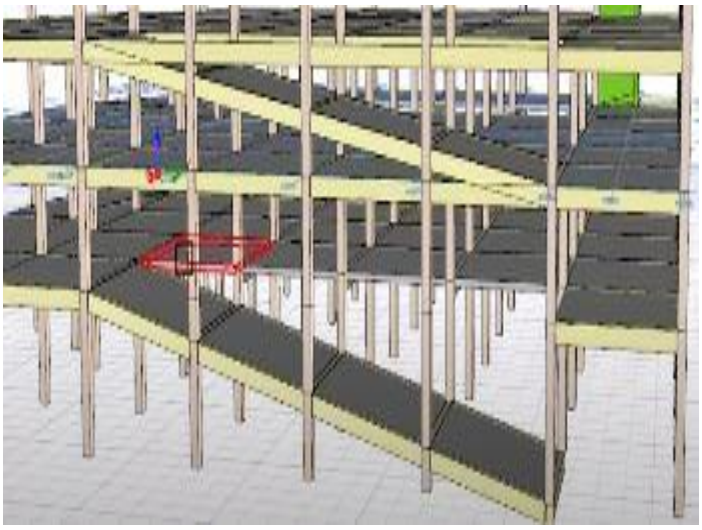


Figure 4 .11 : Ramp structural

Figure 4 . 12 : Stairs structural reinforcement

Costing estimation Bill quantity

Table 4.2 Costing estimation

S/N	Description	Unit	Quantity	Rate (Rwf)	Amount(Rwf)
A Preliminary work					
1	Site levelling and taking away all debris from the site (Dumping)	R.S.	1	5,000,000	5,000,000
2	Site installation	R.S.	1	3,500,000	3,500,000
3	Setting out the Building	R.S.	1	2,000,000	2,000,000
	S/Total				10,500,000
B Substructure					
4	Excavation for foundation 500mm and 1.6m depth	m^3	3035.44	100000	303,544,000
5	Competition inside the foundation around the Building	m^3	47.07	50.000	2,353,500
6	Compaction the room in the foundation	m^3	158.59	30,000	4,757,700
7	Raft concrete on the base foundation around the Building	m^3	28.54	800,000	22,832,000
8	Raft in a room building	m^3	95.15	600,000	57,090,000
	S/Total				390,577,200
C Super Structure					
1	Reinforced concrete sub-column of mixing ratio 1:0.75:1.25	m^3	40	3,000,000	120,000,000
2	Reinforced concrete column	m^3	180	3,000,000	540,000,000
3	Reinforced concrete external beam	m^3	36.49	3,000,000	109,497,600
4	Reinforced concrete internal	m^3	39.62	3,000,000	118,880,640

	beam				
5	Reinforced concrete of slab	m^3	1681.7	1,500,000	2,521,500,000
6	Bricks masonry	pcs	21,093	200	4,218,620
7	Plastering	m^2	51	100,000	5,100,000
8	Painting	m^2	64	30,000	1,920,000
9	Reinforced concrete Stair	m^3	30	300,000	9,000,000
	S/Total				3,430,116,860
	Doors				
1	Single Doors	N	76	200,000	15,200,000
2	Double Doors	N	40	400,000	16,000,000
3	Rotate Doors	pcs	6	1.000.000	6,000,000
4	Hinged Doors	pcs	10	800,000	8,000,000
	S/Total				37,200,000
	Windows				
	Window glazed and steel frame.	N	150	250,000	37,500,000
	Single windows glazed with steel frame	N	120	400,000	48,000,000
	Short windows	N	80	100,000	8,000,000
	accessories	N	200	80,000	16,000,000
	S/TOTAL				109,500,000
Electrical installation					
1	Cables : -2.5mm^2 Alfa cable or equivalent (Rolls) and 1.5 mm^2 , 4 mm^2 , Rolls)	N	40	50,000	2,000,000
2	Socket outlet	N	90	20,000	1,800,000

3	C. B box	N	(200).	15,000	3,000,000
4	Switches	N	100	12,000	1,200,000
5	Lighting system	N	150	20,000	3,000,000
6	Circuit breakers	N	30	40,000	1,200,000
7	P.V.C. Pipes 3/4	N	500	5000	2,500,000
8	Nails anchor bolts	kg	40	2000	80,000
	S/TOTAL				12,780,000
	Plumbing installation				
1	Galvanised Pipes	N	200	15,000	3,000,000
2	P.V.C. Pipes	N	300	10,000	3,000,000
3	Ganga Pipes	N	200	10,000	2,000,000
4	Water Close	N	48	100,000	4,800,000
	S/TOTAL				12,800,000
	Painting				
	Latex Paint	kg	100	60,000	6,000,000
	Oil paint	kg	300	200,000	60,000,000
	S / Total				66,000,000
	ALL TOTAL				4,349,738,060

CHAPTER 5 CONCLUSION AND RECOMMENDATION

Introduction

The purpose of this project is to construct a contemporary market for the residents of Gasogi City and other cross-districts in order to address the issues of infrastructure growth and urban planning. We discovered that the goals were on both sides based on the results of both the designed and the obtained ones.

Analysis, designs and details made for **'Architectural and structural design of modern market with three stories at Gasogi city`** present technical results for ULK POLYTECHNIC students with both economical and safety; the implementation of this market will react as a solution

The dynamic market dynamics of Gasogi, a thriving sector located in Kigali, Rwanda's Gasabo area, are undergoing substantial changes. Gasogi is becoming an important location for both domestic and foreign business as Kigali develops further into a regional economic powerhouse. Gasogi's modern market is defined by the city's fast urbanisation, rising consumer prosperity, and expanding need for a wide range of products and services. Technological developments, shifting consumer preferences, and infrastructure expansion are some of the reasons driving this progression. Businesses looking to enter or grow in Gasogi must comprehend these characteristics in order to successfully traverse the opportunities and difficulties presented by this rapidly expanding sector.

Conclusion

As the result of this comprehensive study, the structural design of the proposed three-story modern market building in Gasabo District has been carefully examined and engineered. The project started with the careful calculation and design of necessary components such as beams, slabs, columns, foundations, and stairs. The construction parameters, like the dimensions of 52.153 m x 42.995 m and the height of 3.80 m for each floor, established the foundation for a sturdy structural framework. The longitudinal beams' flange width of 907 mm, as well as their depth of 800 mm, ensured the structural integrity required for a building of this size. The thoughtful addition of Ø20 mm reinforcement bars at both the top and bottom placements of every beam considerably increased their capacity to support loads.

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The depth of the research done is reflected in the careful design of various building components, such as slabs with different panel kinds and a 15 cm thickness, columns reinforced with Ø40 mm bars and Ø8 mm links, and foundations carefully built considering a bearing capacity of Pb= 550 KN/m2. With a comfortable going of 300 mm, a riser of 305 mm, a flight height of 200 cm, and a pitch of 29.530, the stair design demonstrates a comprehensive approach to user safety and convenience.

This study not only emphasises the use of basic civil engineering principles but also shows how analytical techniques can be used to address intricate structural problems. The planned structure is evidence of the collaboration. Of technical know-how and architectural vision, demonstrating a pleasing harmony of form and function.

In conclusion, this dissertation adds a great deal to our understanding of civil engineering methods in the Gasabo District and offers insightful information about the subtle structural aspects of designing multi-story buildings. The results of this study should prove to be a useful guide for upcoming building projects, encouraging efficiency, safety, and creativity in the field of structural engineering.

Recommendation

Several important recommendations are made in light of the thorough study and design work done for the structural framework of the planned three-story modern market building in Gasabo District. These recommendations are essential to guaranteeing the Building's structural soundness, safety, and long-term durability, particularly given the circumstances in which the soil's carrying capacity was calculated using Kigali City as a reference.

Testing of the soil: It is highly advised that comprehensive soil tests tailored to the construction site be carried out. Crucial information on the composition, settling properties, and bearing capacity of the soil is provided by soil testing. This data guarantees that the foundation can sufficiently support the imposed loads and is essential for precise foundation design.

Quality Assurance of Materials: It is essential to highlight the implementation of strict quality control protocols for all construction materials. Reinforcement bars, concrete mixtures, and other materials must comply with established standards. Continuous testing and quality assessments should be performed throughout the construction process.

Monitoring and Oversight: A comprehensive and ongoing monitoring system should be established during the construction phase. Skilled engineers and supervisors must oversee the project to ensure strict compliance with design specifications, addressing any discrepancies without delay.

Accessibility and Safety Considerations: Evaluate the Building's accessibility, particularly for individuals with disabilities. Incorporate safety features such as handrails and non-slip surfaces in key areas, including stairs and balconies, to mitigate the risk of accidents.

Community involvement: Engage the local community and relevant stakeholders throughout the construction process. It is essential to address any concerns they may express and to uphold transparent communication. The support and comprehension of the community can play a crucial role in facilitating a seamless construction experience. By implementing these suggestions, the planned three-storey apartment building in Gasabo District can not only adhere to the required safety regulations but also serve as a symbol of community collaboration.

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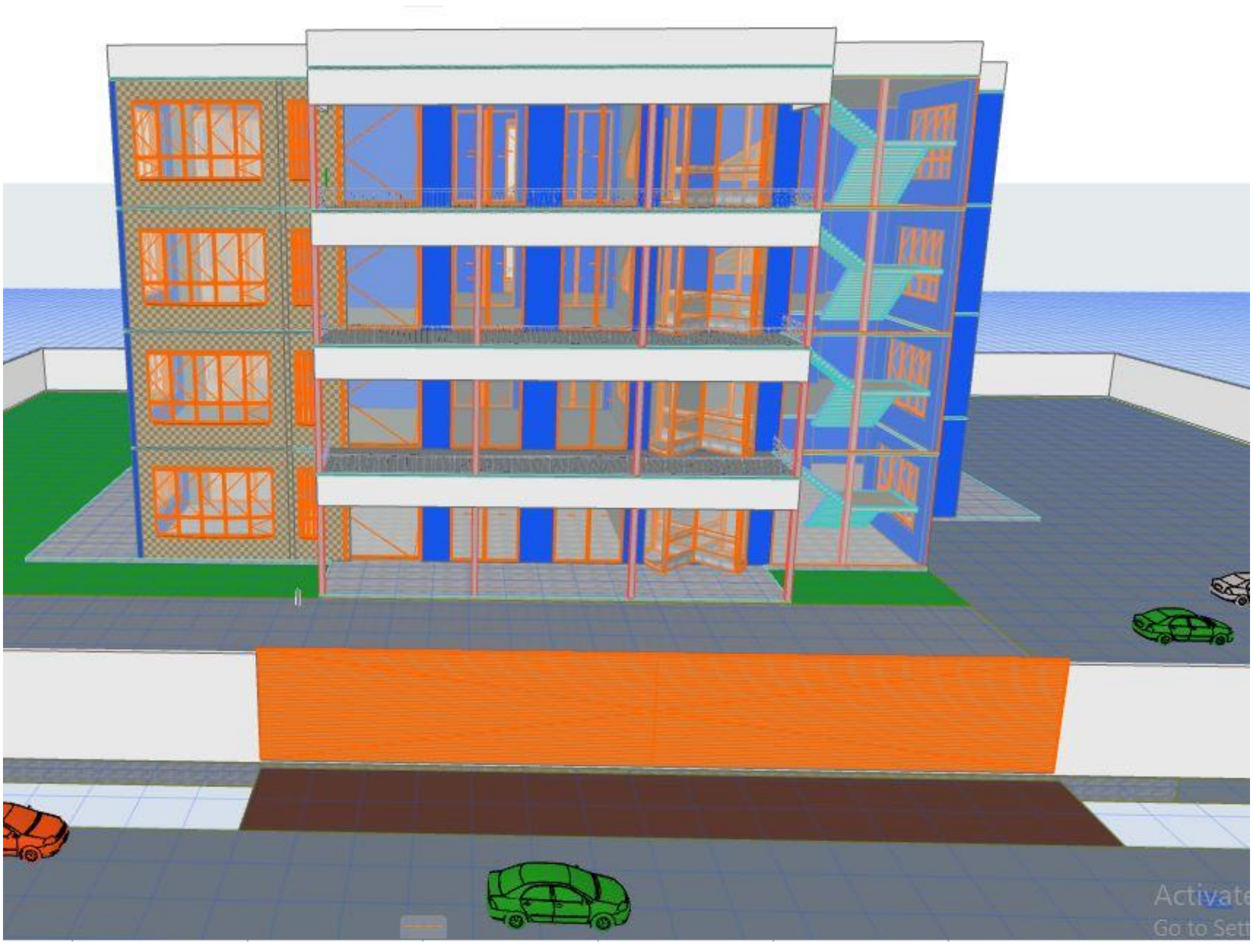
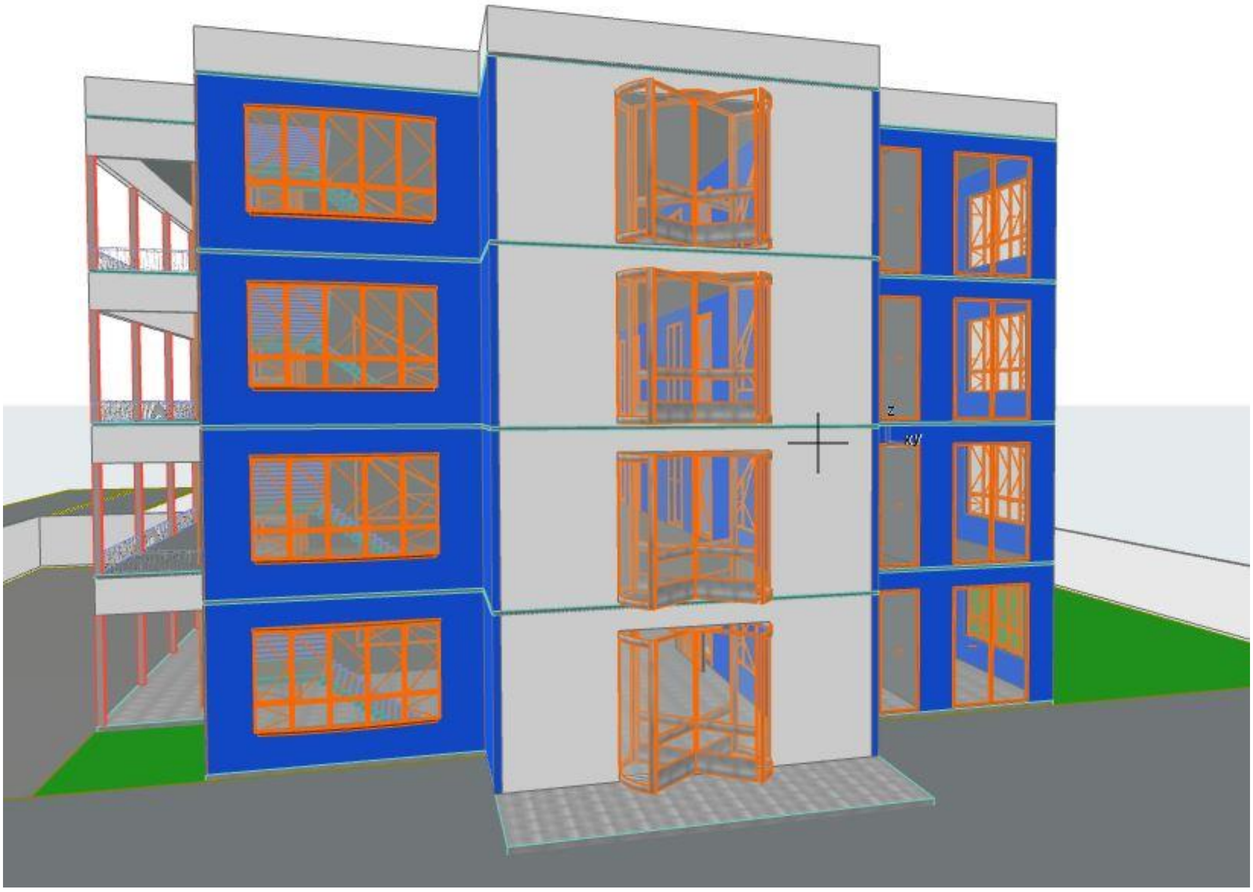
APPENDICES

Appendix 1: Front View of the Building

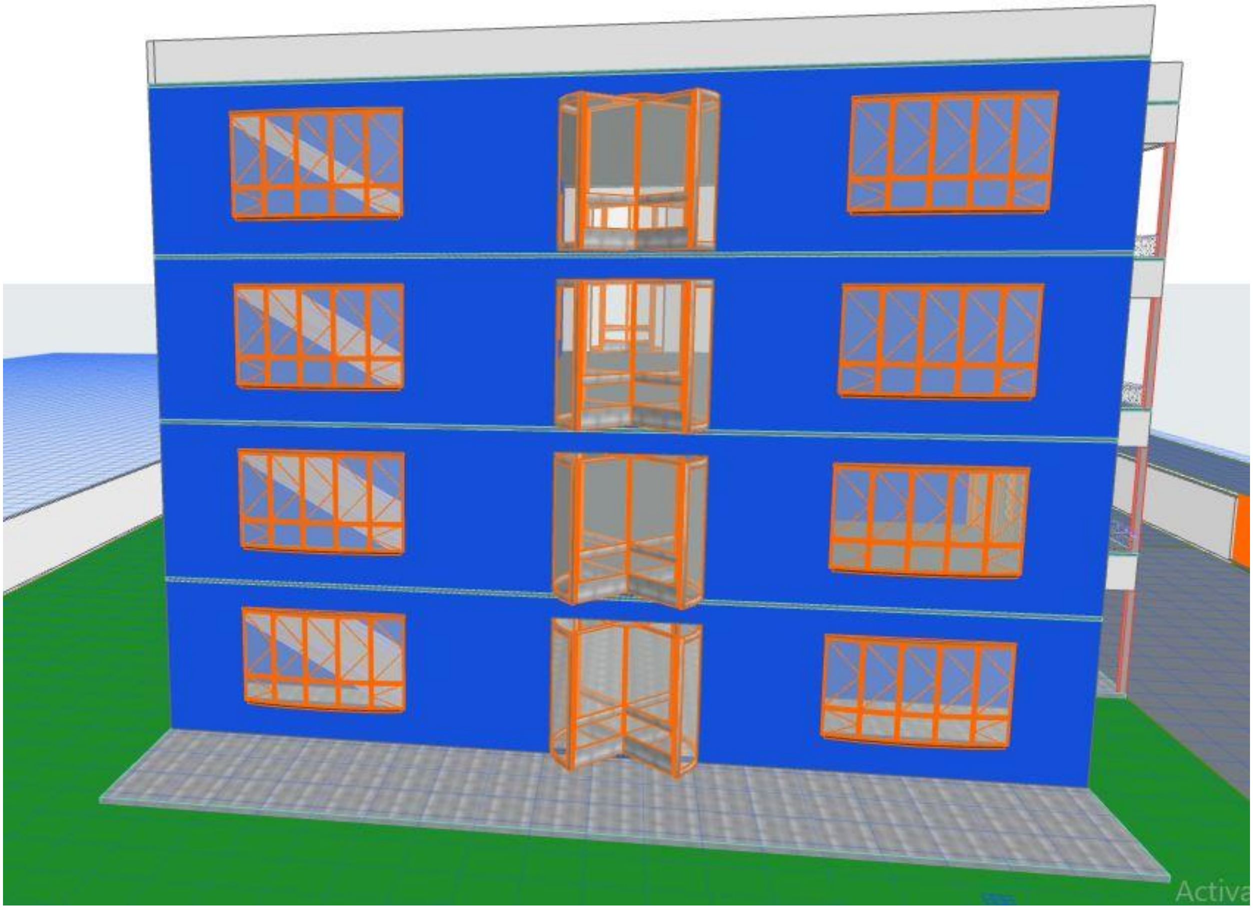


Appendix 2: Back view of the Building

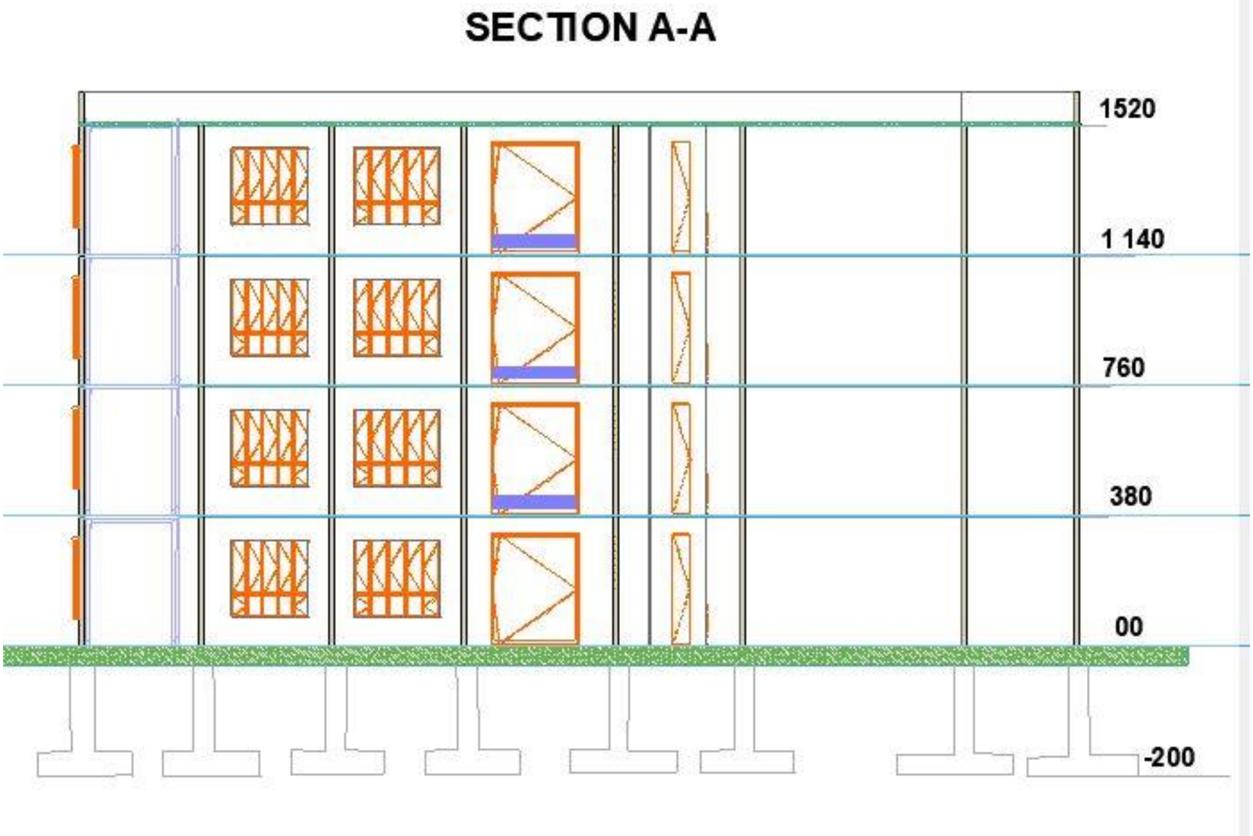
Appendix 3: Right View of the Building



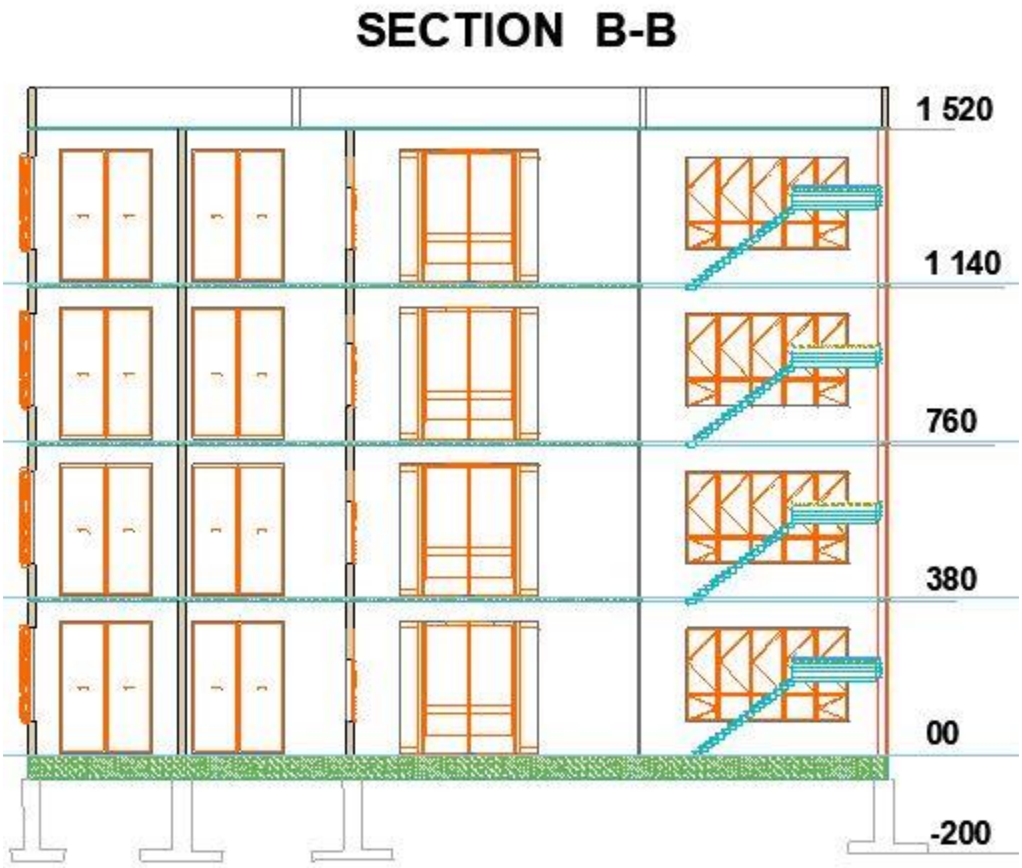
Appendix 4: Left view of the Building



Appendix 5: Section A-A of the Building



Appendix 6: Section B B of the Building



Appendix 7: Perspective of the Building

Appendix 8: Areas of Group of Bars

Diamenter (mm)	*Number of bars in groups*							
	1	2	3	4	5	6	7	8
6	28	56	84	113	141	169	197	226
8	50	100	150	201	251	301	351	402
10	78	157	235	314	392	471	549	628
12	113	226	339	452	565	678	791	904
16	201	402	603	804	1005	1206	1407	1608
20	314	628	942	1256	1570	1884	2199	2513
25	490	981	1472	1963	2454	2945	3436	3927
32	804	1608	2412	3216	4021	4825	5629	6433

Appendix 9: Bars Spacing

Bar size (mm)	Spacing of bars								
	50	75	100	125	150	175	200	250	300
6	566	377	283	226	189	162	142	113	94.3
8	1010	671	503	402	335	287	252	201	168
10	1570	1050	785	628	523	449	393	314	262
12	2260	1510	1130	905	754	646	566	452	377
16	4020	2680	2010	1610	1340	1150	1010	804	670
20	6280	4190	3140	2510	2090	1800	1570	1260	1050
25	9820	6550	4910	3930	3270	2810	2450	1960	1640
32	16100	10700	8040	6430	5360	4600	4020	3220	2680
40	25100	16800	12600	10100	8380	7180	6280	5030	4190

Appendix 10: Chart of Air of Rectangular Column

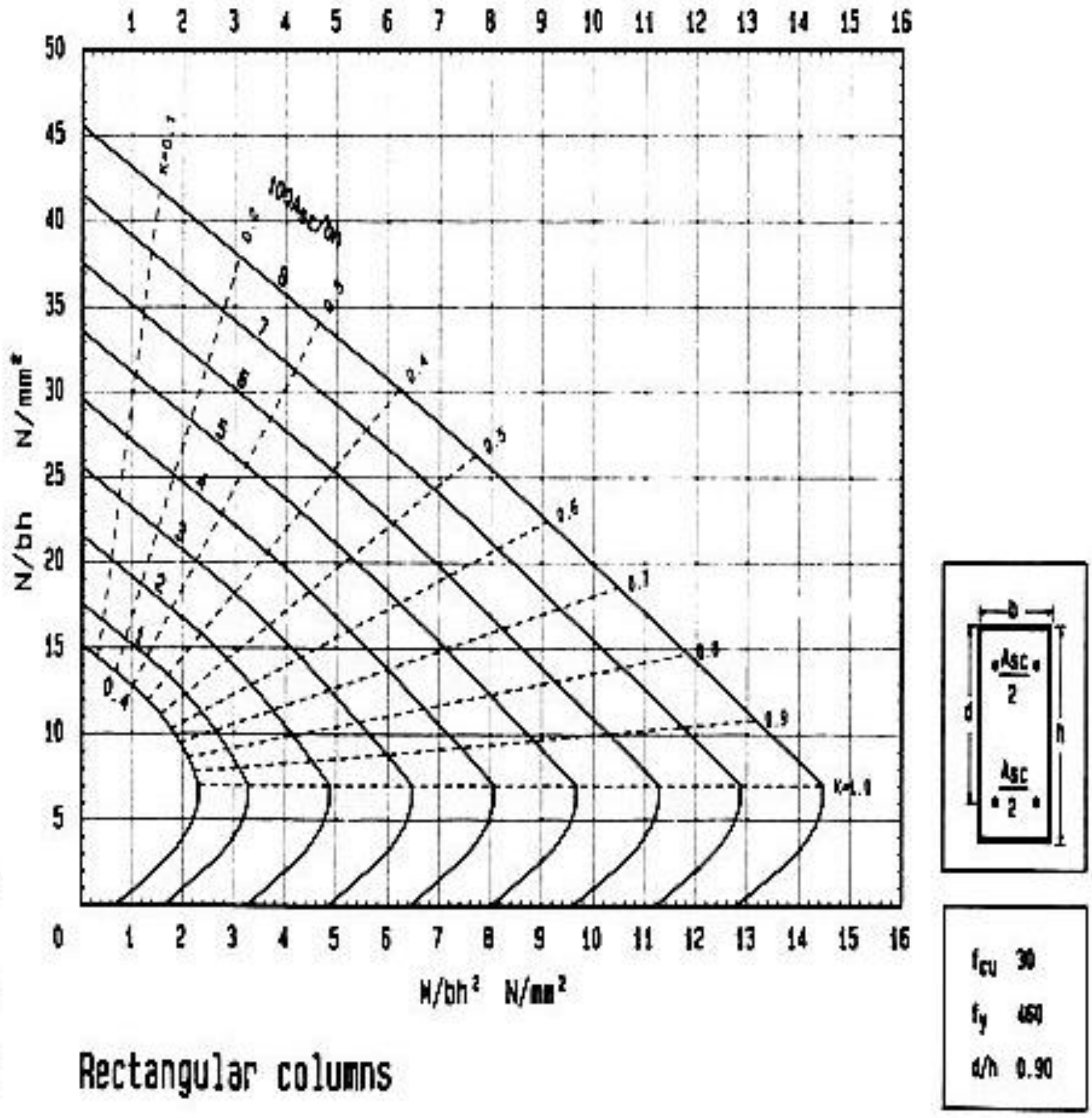


Chart No. 29

Rectangular columns