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DEPARTMENT OF CIVIL ENGINEERING

OPTION OF CONSTRUCTION TECHNOLOGY

STRUCTURAL DESIGN OF G+2 BUILDING

CASE STUDY: RESIDENTIAL APARTMENT AT GISOZI

Submitted in partial fulfilment for the requirement of the award of advanced diploma in Construction Technology.

Presented by:

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Under guidance of: Eng. Bonaventure NKIRANUYE

Kigali, October, 2024

DECLARATION

I**, ARAKIZA Janvier (202150263)** declare that no portion of this work has been submitted to the application of any other degree or qualification in this or any other university or institution of higher learning, except where specifically acknowledged, it is the work of the authors.

Name Signature

ARAKIZA Janvier **(202150263)** ……………………………………………..

Date:…………/10/2024

CERTIFICATION

This is to certify that the project entitled **"Structural design of G+2 building; Case study: Residential apartment at Gisozi"**is the original work done **ARAKIZA Janvier (202150263).**The project was carried out under my supervision and to the best of my knowledge the project has not in any part been submitted in any other academic institution.

Eng. Bonaventure NKIRANUYE	Eng. Annoncee MUKESHIMANA
Supervisor	Head of Civil Engineering department
Date…………………………………	Date………………………….

DEDICATION

This project is dedicated to:

- To almighty God, for his support and guidance in undertaking this undergraduate degree program,
- To ULK Polytechnic Institute
- To my Supervisor Eng. Bonaventure NKIRANUYE
- To the Head of Civil Engineering department,
- To my family for their encouragement and support,
- To my relatives and friends for being on my side,
- To my Lectures

ABSTRACT

In order to ensure the building stability, it was necessary to determine the adequate dimensions of structural elements; this project deals with the calculation and design of reinforced concrete structure. Several figures and tables have been used to illustrate the text and contribute to a better understanding of the subject matter.

The proposed apartment building is 23.25 m x 18 m dimensions. It is three-storey building and it has bedrooms, living rooms, dining rooms and bathrooms. The height of each floor is 3.20 m.
All the building members (slabs, columns, foundations and stair) are calculated by analytical method by using the basic knowledge in civil engineering.

The height of the beam is 55 cm; its width is 20 cm whereas the width of flange is 90.7 cm for longitudinal beams. The maximum and minimum bar of reinforcement bar at top for all beams is Ø16 the same to the reinforcement at bottom.
The critical panel of slab was designed, slab thickness is 15cm the maximum size of reinforcement bar is Ø12mm .The high loaded column was designed and the maximum reinforcement bar size is Ø25mm.Links of Ø8 mm at 300 mm center to center were provided to hold main reinforcement bars.

Foundation were designed by considering the bearing capacity Pb= 320 KN/m^2 and designed upper load from columns. Each designed foundation is 200*200*50 cm and the maximum reinforcement bar is Ø20 mm in foundation.

In order to provide access from floor to next floor stair was designed .Going of stair is 300 mm, riser is 150 mm, the flight height is 160 cm and its pitch is 29.53^0, that stair is reinforced by Ø16 mm.

Key words: Structural design, architectural design, geotechnical study.

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LIST OF SYMBOLS

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 ultimate loads (at support for cantilever).

As: minimum recommended area of reinforcement.

As´: area of compression reinforcement.

As' prov: area of compression reinforcement.

Asc: area of steel in compression

Asv: area of steel in vertical links

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

bw: average web width of a flanged beam

d: effective depth of the tension reinforcement.

d: depth to the compression reinforcement.

fcu: characteristic strength of concrete.

fy: characteristic strength of reinforcement.

Gk: characteristic dead load.

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

hf: thickness of the flange.

l: span of the beam.

lc: dimensions of the column measured in the same direction as lh.

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

lo: clear height of the column

lx: length of shorter side.

lx: shorter span of flat slab panel.

ly: length of longer side.

ly: longer span of flat slab panel.

M: design 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

Mx: moment on the column in x direction

N: design axial force.

Nd: service load on foundation

Nd: axial load on the column

ϕ: diameter of steel.

Pmax: maximum pressure on footing

Pmin: minimum pressure on the footing

RA: reaction to the support A

RB: reaction to the support A

Qk: characteristic imposed load.

Sv: spacing of links along the member.

V: Design shear force due to ultimate loads.

Vsx, Vsy : design shear capacity of shear reinforcement

W: self weight of the foundation

X: depth to the neutral axis.

Z: lever arm

βb: the ratio of redistributed moment over elastic analysis moment

βsx and **βsy**: moment coefficients shown in Table 3.13.

βsx and **βsy**: moment coefficients shown in Table 3.14.

βvx and **βvy:** shear force coefficients shown in Table 3.15.

βx: sagging moment in the span, per unit width, in the direction of the shorter span, **lx**, divided

βy: sagging moment in the span, per unit width, in the direction of the longer span, **ly** divided

V: Shear stress.

V_C: Shear capacity of concrete

γm: partial safety factor for the strength

LIST OF ABBREVIATIONS

BS: British standard

ULK: Université Libre de Kigali

M.F or **M.f:** Modification fact

R.C: Reinforced concrete

RA: reaction to the support A

RB: reaction to the support A

Qk: characteristic imposed load.

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CHAPTER 1.GENERAL INTRODUCTION

1.1.Background of the study

Rwanda is the most densely populated and fastest growing country in Africa with a growth rate of 10.7%. The country's total population is currently 10.6 million (NISR, 2011), of which about 1 million live in Kigali city. The population in Kigali city is expected to increase to about 3 million by 2020. Attracted to the growing economic opportunities, people from the rural areas are moving to the city, creating a large demand for affordable housing. The housing demand and housing supply levels arising from the falling levels of public funding, insufficient incomes, and the sheer scale of population growth and the huge rates of urbanization aggravates the matter.

According to the national human settlement policy in Rwanda, the government recognizes the fundamental right to housing for every citizen as specified in international instruments to which Rwanda has subscribed, including the Istanbul declaration and the programme for human settlements (June 1996), the millennium development goals (February 2002), the world summit on sustainable development (July – august 2002). To this end, it is determined to provide the population with easy access to decent housing and to protect and improve the conditions of housing and residential areas. This policy stimulated the researchers to participating into human settlement development by planning a project of constructing residential house to answer to housing needs that is rising in Kigali city.

1.2.Problem statement

One of the major problem in Rwanda country facing the rapidly growth of population this can be solved to a certain extent with the construction of multi storied apartments, which can be live many people in available area. The proposed site for this project is at Gisozi sector in Gasabo district.. The project consists of 12 houses in three floors with all basic amenities. It is most economical in design and construction and followed as per limit state design method.

Therefore, means should be revised to balance among the conflicting effects. One such means is the construction of storey structures, which minimize the use of land and maximize the use of space above the land.

It is therefore for these reasons, this project has been chosen to contribute to the development of the country and achieve the goals, as it is described in the project.

1.3. Research objectives

1.3.1. Main objective

The main objective of this project is to do structural design of G+2 building

1.3.2 .Specific objectives:

The following specific objectives are pursued in order to achieve the main objective stated above:

- To provided plan view, perspectives, elevations, cross sections of building;
- To provide the structural drawing
- To design the critical structural members

1.4.Scope and limitation of the study

This project will cover only the area where the apartment building is located and related to the following points;

- Architectural drawing of structure (such as floor plans, sections, elevations and perspectives).
- Structural design of structure (slabs, Beams, Columns, Foundations, Stairs and Ramp)

1.5.Significance of the study

1.5.1.Personal benefits

- Improving professional capacity;
- Increasing skills in construction domain such as design, building, and implementation;
- The benefit of this research is getting knowledge on this project by representing a good research which will help to improve knowledge;
- This study enabled the researcher to be more familiar and get more experience of coordinating such kind of project after school.

1.5.2.Academic benefits

- This report may help in the future as a basic and guide for reference for others researchers and other academics references
- This report may be used by any other person as a reference document about apartment project in different location of any country

- This report may also be used by students and teachers as a reference document during apartment project
- This research gives an inspiration to students and researchers to work on different elements in Rwandans to the apartment especially their feasibilities and their impacts.
- Finding from their study can be used for further researchers.

1.5.3.Public and administrative benefits

- Enhancing living standard of the society;
- Giving jobs to people during the construction of the apartment and its service;
- The government may use this project for stimulating investors and try to find founds from international organization of education;
- It can be used by government as one of plan of reaching their goals of increasing skills to any person as fixed in objectives government to be achieved in 2050;

1.6.Organization of the study

This research is divided into five main chapters in order to provide clarity and coherence on the discussions of all investigations carried out on architectural and structural design of multi-storey building.

CHAPTER 1: General introduction which deals with Introduction, problem statement, research objectives, scope of the research, significance of the research, and finally organization of the study

CHAPTER 2: Literature review, to give all the details and theories concerning architectural and structural design of multi-storey

CHAPTER 3: Materials and Methods, which deals with the methods, procedures, the definitions of the instruments that were used for the investigations and, the methods and techniques, used to collect all the data required.

CHAPTER 4: Results and discussions, which deals with the presentation, analysis and interpretation of the findings.

CHAPTER 5: Conclusion and recommendations, which is the last, present conclusion, recommendations to state the output of the research

CHAPTER 2.LITERATURE REVIEW

2.1. Reinforced concrete structure

This is a composite material with steel bars incorporated within the concrete in order to meet some desired properties.

Important to remember is that mass concrete is very weak in tensile forces(tension), strong in compression, has a good fire resistance capacity while steel is good in both tension and compression but easily corrodes if not well protected and above all, steel yields rapidly at very high temperatures.

Therefore, a combination of two materials to form one composite substance is of vital help to a structural engineer. Thus, they combine and meet the desired properties. E.g.: Durability, strength, etc for a structural engineer's structure.

2.1.1. Concrete

Plain concrete is a mixture of fine aggregate, water, cement and coarse aggregate. All the components of the plain concrete are mixed together until they became paste, which surrounds the voids in aggregate during its fresh concrete.

The steel bars are placed into firms and concrete paste is filled around the steel bars until it changes from a plastic to a solid state about 24 hours, to become hard. The expected outcomes of concrete properties are affected by their ingredients, which are expected to give reasonable data as designed in beginning. Compressive strength, modulus of elasticity and Poisson's ratio are also expected to give good agreement at 7, 14 and 28 days tests.

As a result, the good homogenous material gives a good relation with embedded steel bars in concrete forms. Therefore, the expected outcome will be more accurate not only for good homogenous between the composite materials but also during cure cycle (Farah M. Wegian, PhD, 2005)

a) Ingredients of concrete

Cement

Cement is described as the material that has adhesive properties that make it capable of binding other material fragments into a compact mass. In present day concrete, cement is a mixture of limestone and clay heated in a kiln to 1400-1600^{0}c (IS 1343-1980 (Clause 4.1)

Ordinary Portland cement is the commonest type in use. The raw materials from which it is made are lime, silica, alumina and iron oxide. These constituents are crushed and blended in the correct proportions and burnt in a rotary kiln. The clinker is cooled, mixed with gypsum and ground to a fine powder to give cement. The main chemical compounds in cement are calcium silicates and aluminates.

When water is added to cement and the constituents are mixed to form cement paste, chemical reactions occur and the mix becomes stiffer with time and sets. The addition of gypsum mentioned above retards and controls the setting time.

Aggregates

Aggregates make up about 75% of the volume of concrete, so their properties have a large influence on the properties of the concrete (Alexander and Mindess, 2005). Aggregates are granular materials, most commonly natural gravels and sands or crushed stone, although occasionally synthetic materials such as slugs or expanded clays or shales are used.

Most aggregates have specific gravities in the range of 2.6 to 2.7, although both heavyweight and lightweight aggregates are sometimes used for special concretes, as described later. The role of the aggregate is to provide much better dimensional stability and wear resistance; without aggregates, large castings of neat cement paste would essentially self-destruct upon drying. Also, because they are less expensive than Portland cement, aggregates lead to the production of more economical concretes. In general, aggregates are much stronger than the cement paste, so their exact mechanical properties are not considered to be of much importance (except for very high-strength concretes).

Of course, all aggregates should be clean. That is free of impurities such as salt, clay, dirt, or foreign matter. As a matter of convenience, aggregates are generally divided into two size ranges: coarse aggregate, which is the fraction of material retained on a No. 4 (4.75-mm) sieve, and fine aggregate, which is the fraction passing the No. 4 sieve but retained on a No. 100 (0.15-mm) sieve. (D.H Knepper; 1995)

Mixing water

Water plays an important part in the concrete mix. Its principal uses are to make the mix workable and to start hydration .Any material that is in the water that retards or changes the hydration process is detrimental. In many specifications, the quality of water is covered by a clause saying that water should be fit for drinking (this is not unshakable rule because there are some chemicals we may find in drinkable water which are not harmful to human health but they are for concrete, however in general it seems to be a good rule to use drinkable water for concrete) and we call it ordinary water.

The materials found in some types of water include organic compounds, oil, alkali, or acid. Each has its effects on the hydration process. Organic material and oil tend to coat the aggregate and cement particles and to prevent the full chemical reaction and adherence. The organic material may also react with the chemicals in the cement and create a weakened cementing action, thus contributing to deterioration and structural failure of the concrete. Alkalis, acids and sulphates in the water tend to react with the chemicals in the cement .The result is inadequate cementing and weakened concrete .Water must be free from these chemicals to be used in concrete mixing.(Somayaji,shan 2001)

2.1.2. Reinforcement

All the other materials discovered and used in the construction industry were either too weak (timber) too bulky (stone and concrete). So, steel was found to have satisfied to a greater percentage of these desired properties and hence adopted in the construction industry. The reinforcing bars can either be produced as hot rolled mild steel bars having yield strength of 259 Nmm^{-2} or hot rolled and cold worked high yield steel with a characteristic strength of 460Nmm^{-2}.

Reinforcing bars are produced in two grades: hot rolled mild steel bars have yield strength fy of 250 N/mm^2; hot rolled or cold worked high yield steel bars have yield strength fy of 460 N/mm^2. Steel fabric is made from cold drawn steel wires welded to form a mesh; it has a yield strength fy of 460 N/mm^2.

The hot rolled bars have a definite yield point. A defined proof stress is recorded for the cold worked bars. The value of Young‘s modulus E is 200 KN/mm^2. (T.J. Mac Ginley and B.S. Choo, 1990).

2.2. Structural design

The method recommended is limit state design where account is taken of theory, experiment and experience. It adds that calculations alone are not sufficient to produce a safe, serviceable and durable structure. Correct selection of materials, quality control and supervision of construction are equally important.

The criterion for a safe design is that the structure should not become unfit for use, i.e. that it should not reach a limit state during its design life.

2.2.1. Aims and methods of design

The aim of design is the achievement of an acceptable probability that the structure will perform satisfactorily during its life. It must carry the loads safely, not deform excessively and have adequate durability and resistance to effects of misuse and fire.

The clause recognizes that no structure can be made completely safe and that it is only possible to reduce the probability of failure to an acceptably low level.

The method recommended in the code is limit state design where account is taken of theory, experiment and experience. It adds that calculations alone are not sufficient to produce a safe, serviceable and durable structure. Correct selection of materials, quality control and supervision of construction are equally important.

2.2.2. Criteria for safe design-limit states

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

a. **The ultimate limit state**—the whole structure or its elements should not collapse, overturns or buckles when subjected to the design loads.
b. **Serviceability limit states**—the structure should not become unfit for use due to excessive deflection, cracking or vibration the structure must also be durable, i.e. it must not deteriorate or be damaged excessively by the action of substances coming into contact with it. The code places particular emphasis on durability. For reinforced concrete structures the normal practice is to design for the ultimate limit state, check for serviceability and take all necessary precautions to ensure durability.

2.2.3. Characteristic and design loads

The characteristic or service loads are the actual loads that the structure is designed to carry. These are normally thought of as the maximum loads, which will not be exceeded during the life of the structure. In statistical terms, the characteristic loads have a 95% probability of not being exceeded.

The characteristic loads used in design and defined in BS8110 are as follows:

1. The characteristic dead load Gk is the self-weight of the structure and the weight of finishes, ceilings, services and partitions.
2. The characteristic imposed load Qk is caused by people, furniture, and equipment etc. on floors and snow on roofs.
3. The wind load Wk depends on the location, shape and dimensions of the buildings

Load combinations

Separate loads must be applied to the structure in appropriate directions and various types of loading combined with partial safety factors selected to cause the most severe design condition for the member under consideration. In general, the following load combinations should be investigated.

i. Dead load Gk+imposed load Qk

1. All spans are loaded with the maximum design load of 1.4Gk+1.6Qk;
2. Alternate spans are loaded with the maximum design load of 1.4Gk+ 1.6Qk and all
3. Other spans are loaded with the minimum design load of 1.0Gk.

ii. Dead load Gk + wind load Wk

If dead load and wind load act in the same direction or their effects are additive the load combination is 1.4(Gk + Wk). However, if the effects are in opposite directions, e.g. wind uplift, the critical load combination is 1.0Gk−1.4Wk.

Table 2.1: Load combination (Bath, 2002)

Load Combination	Load type					
	Dead load		Imposed load		Earth and Water pressure	Wind
	Adverse	Beneficial	Adverse	Beneficial		
1. Dead and imposed (and earth and water pressure)	1.4	1.0	1.6	0	1.4	_
2. Dead and wind (and earth and water pressure)	1.4	1.0	_	_	1.4	1.4
3. Dead, wind and imposed (and earth and water pressure)	1.2	1.2	1.2	1.2	1.2	1.2

2.2.4. Reinforced concrete slabs

In reinforced concrete construction, slabs are used to provide flat, useful surfaces. A reinforced concrete slab is a broad, flat plate, usually horizontal, with top and bottom surfaces parallel or nearly so. It may be supported by reinforced concrete beams (and is usually cast monolithically with such beams), by masonry or reinforced concrete walls, by structural steel members, directly by columns, or continuously by the ground.

Slabs may be supported on two opposite sides only, as shown in Fig.2.1, in which case the structural action of the slab is essentially one-way, the loads being carried by the slab in the direction perpendicular to the supporting beams.

a) Slab reinforcement design

A one-way slab needs movement resisting reinforcement only in its short-direction because the movement along long axes is so small that it can be neglected. When the ratio of the length of long direction to short direction of a slab is greater than 2 it can be considered as a one way slab.

Long direction: ly

Short direction: lx

One-way slab it can be;

$$\frac{\mathrm{Ly}}{\mathrm{Lx}} > 2$$

A two-way slab needs movement resisting reinforcement in both directions. If the ratio of the lengths of long and short side is less than two then movement in both directions should be considered in design.

Two-way slabs it can be;

$\frac{\mathrm{Ly}}{\mathrm{Lx}} < 2$ (Jack C. Mc Cormarc and Russell H. Brown, 2015)

2.2.5. Beam

A beam is a structural element that is capable of withstanding load primarily by resisting against bending. The bending force induced into the material of the beam as a result of the external loads, own weight, span and external reactions to these loads is called a bending moment. Their profile (shape of cross-section), their length, and their material characterize beams.

Beams are traditionally descriptions of building or civil engineering structural elements, but smaller structures such as truck or automobile frames, machine frames, and other mechanical or structural systems contain beam structures that are designed and analyzed in a similar fashion. (Jack C. Mc Cormac and Russell H. Brown, 2015)

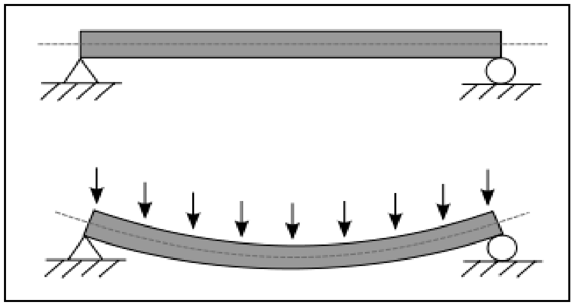


Figure 2.1: Beam shape and bend

a) Classification of beams based on supports

In engineering, beams are of several types:

- Simply supported - a beam supported on the ends, which are free to rotate and have no moment resistance.
- Fixed - a beam supported on both ends and restrained from rotation.
- Over hanging - a simple beam extending beyond its support on one end.
- Double overhanging - a simple beam with both ends extending beyond its supports on both ends.
- Continuous - a beam extending over more than two supports.
- Cantilever - a projecting beam fixed only at one end.
- Trussed - a beam strengthened by adding a cable or rod to form a truss.

(Jack C. McCormac and Russell H. Brown, 2015)

2.2.6. Reinforced concrete column

A reinforced concrete column is a structural member designed to carry compressive loads, composed of concrete with an embedded steel frame to provide reinforcement. For design purposes, the columns are separated into two categories: short columns and slender columns.

(W.H. Mosley and J. H. Bungey, 1987)

a) Short Columns

The strength of short columns is controlled by the strength of the material and the geometry of the cross section. Reinforcing rebar is placed axially in the column to provide additional axial stiffness. Accounting for the additional stiffness of the steel, the nominal loading capacity for the column in terms of the maximum compressive stress of the concrete, the yield stress of the steel, the gross cross section area of the column, and the total cross section area of the steel rebar.

b) Slender Columns

Columns qualify as being slender when their cross sectional area is very small in proportion to their length. Unlike Short Columns, Slender Columns are limited by their geometry and will buckle before the concrete or steel reinforcement yields.

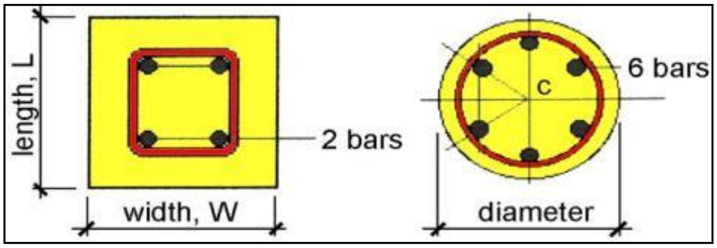


Figure 2.2: Column section

2.2.7. Foundation

A foundation is the lowest part of a structure and is designed based on column loads and moments at base and the soil data. Design loads for foundation design; loads for determination of size of foundation the condition to be satisfied by the subsoil in the design of foundation is that the loads from the structure should not exceed its safe bearing capacity (which is based on both strength and settlement). (P.C.Varghese, 2009)

2.2.8. Footing

The footing is the bottom part of the foundation. It's the base sometimes called a "spread footing" because it's spread wide and it spreads the vertical loads that are coming down in the building.

Footings are an important part of foundation construction. They are typically made of concrete with rebar reinforcement that has been poured into an excavated trench. The purpose of footings is to support the foundation and prevent settling. Footings are especially important in areas with troublesome soils.

The construction of footings is best left to the pros that can assess the soil conditions and decide on the proper depth and width for the footings as well as the proper placement. The dimensions of footings also depend on the size and type of structure that will be built. Placement of footings is crucial to provide the proper support for the foundation and ultimately the structure. (P.C.Varghese, 2009)

CHAPTER 3. MATERIALS AND METHODS

3.1. Introduction

This chapter focuses on different techniques used in the proposed project design concept even of a apartment building.In addition, it contains methods used to carry out the research and it has the following sub-topic: data type and sources, data collection, data processing, presentation of data and data analysis.

3.2. Choice of methodology

A successful research depends on the choice of convenient methodology used in that research. If you have carried out a convenient research methodology, it's very easy to get good results. Some information is necessary to be able to determine design load and structural details of structural elements such as columns, slabs, foundations ,stairs and beams. In this research we will need to know bearing capacity of the soil and compare it to the design load from the building.

3.3. Methods and Approaches

The design approach would comprise of an integrated design process, and a sustainable way of approaching hotel designing, there by optimizing the interplay between the architectonic merit and its functional application and expressions. The indoor climate "ventilation", acoustics, statics analysis and construction management would be considered and dealt with as part of the design parameters.

The integrated Design Process involves the following design parameters:

Problem formulation: Explanatory of the project idea or problems that requires much attention for better solutions.

Analysis phase: The site registration of genius loci, in relation to wind, sun topography of the terrain, functions, indoor climate and theories to give a profound understanding of the design parameters.

Sketching phase: This phase involves the architectural approaches in regards to the functional demands, testing of ideas, and the merits of evaluating solutions in different perspective and those that have the potential to fulfill the design criteria as determine in the Analysis phase.

Synthesis phase: The synthesis phase is where the building finds its form, and base on the various computation and optimization of the design parameters to achieve the design goal as stated in the Analysis phase of the program.

Presentation phase: The finish project is handover in report form, whereby an examination follows including digital presentation, models and an oral defending of report [Knudstrup, 2008]

3.4. Description of the area of study

Gisozi sector is located in Gasabo district of Kigali city, Rwanda. This sector is characterized by a small cluster of houses and buildings, and is geographically located at 1° 55' 6" South latitude and 30° 3' 23" East longitude (latitude/longitude -1.9185.30.0565. It is located in a tropical region. The administrative structure includes two cells and 14 villages) as shown in Figure 3.2. It is bounded by Jabana sector in the North, Kinyinya sector in the East, Muhima sector in the South and Gatsata sector in the West as shown on Figure 3.1. Gisozi stands out as one of the 15 sectors of Gasabo district and contributes to the overall urban fabric of Kigali City. While Figure 3.3 presents the existing and planned roads network of Gisozi sector.

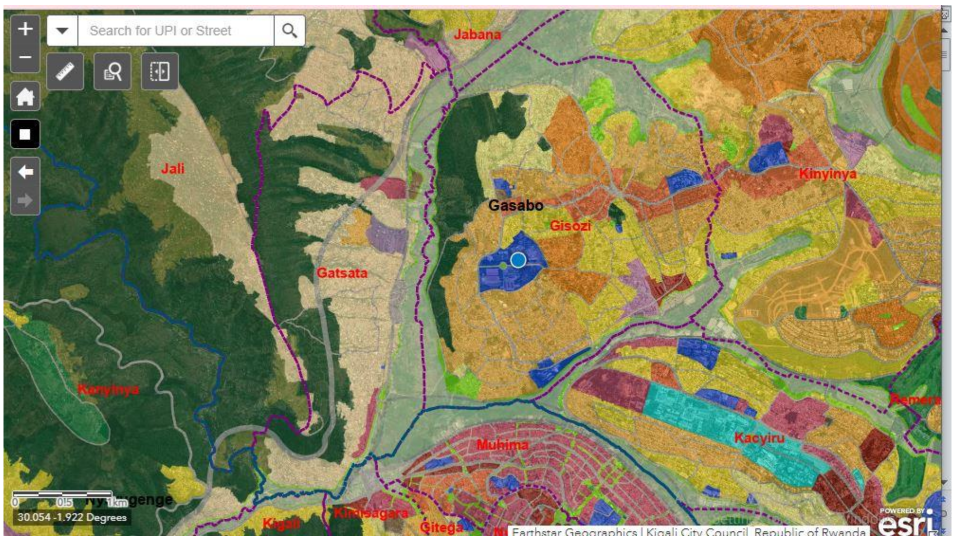


Figure 3.1: Location of Gisozi sector to the neighboring sectors

Source: Kigali Master Plan

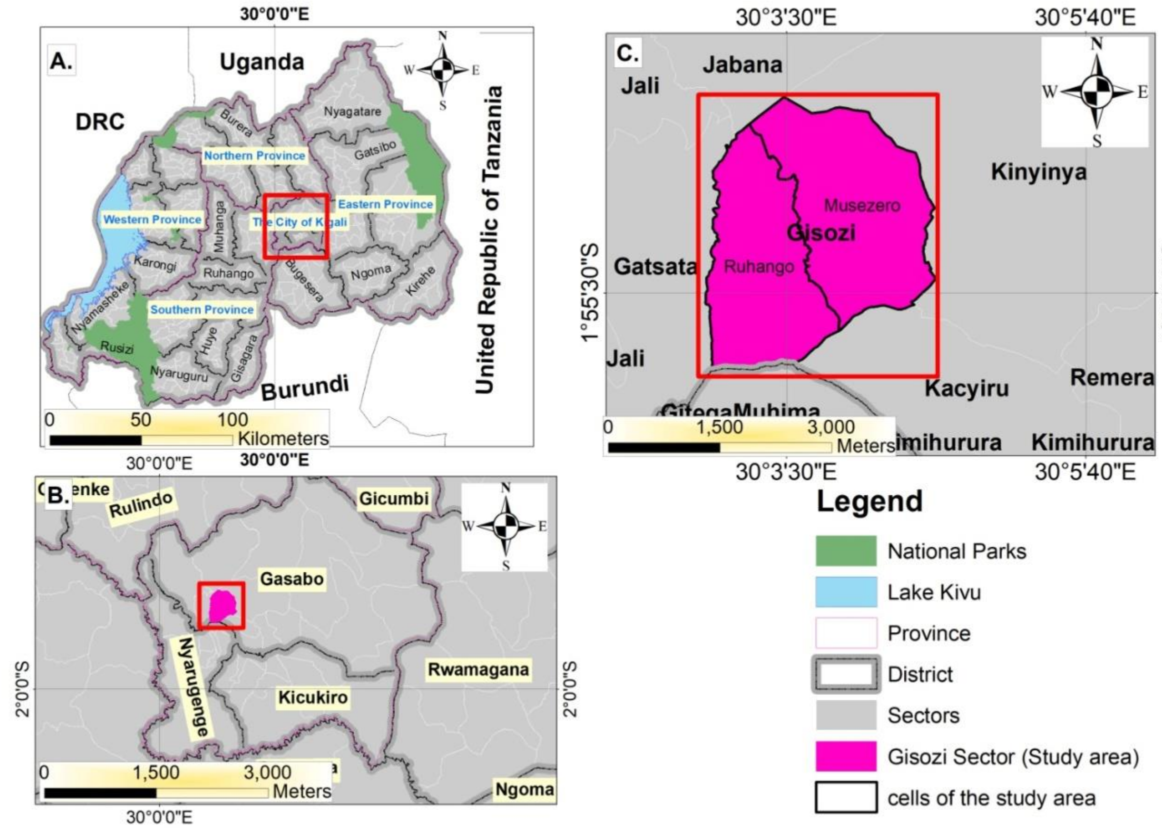


Figure 3.2. Map of the study area

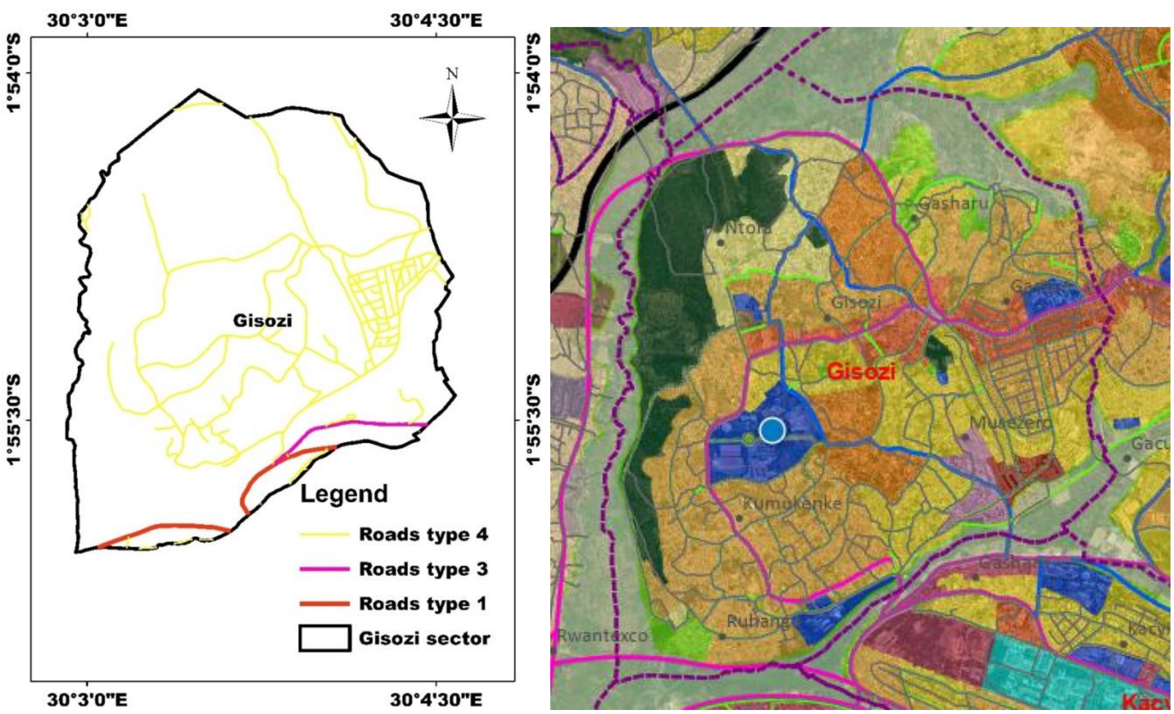


Figure 3.3. Existing and proposed roads of Gisozi sector

3.5. Site observation

The site visit is necessary where the project is to be implemented in order to see if the concerned area is located where is possible to construct with respect the government regulations, if the accessibility is available to the users and if parcel is enough related to the building dimensions and also if four stars hotel building is needed there. The site is located in Kigali City, Gasabo district, Gisozi sector. The site has access to water and electricity.

3.6. Data types

There were a lot of data types that was involved during the project study and completion, and some of these are:

- Texts and drawings that are from different coefficients, chats, tables, unit weights off different structures.
- The rules of writing the book and also architectural plans standard.
- Formulas and methods of calculation and designing members.
- Different ways of presenting project
- Bearing capacity of the soil

3.7. Data source

The data used in this book are from:

- Different books and code of standard especially British standard.
- Research from internet access.
- Notes from lectures notes.
- Site itself and Gasabo location.

3.8. Data collection

- Those data are collected by using visual basic during the visit of the site.
- Reading and writing down information from means stated above
- Oral interview**:** Kigali master plan implementation and One Stop Center have been consulted in order to get the required information to perform the project.

- Site observation**:** Field visits have been done in order to observe the type of terrain, the shape of the plot and the existing buildings.

3.9. Data processing

The processing of the data is treating those ones. This is achieved the real data collected and put them in practice to achieve the objective. The methods that are followed in this proposed project are:

1. Interpretation of drawings and charts and tables.
2. Taking data and treat them using formulas from different parts of B.S Codes.
3. The use of soft ware such as SAP 2000during calculation of bending moments and shear forces.

3.10. Soil investigation

According to the laboratory tests carried out in ULK Polytechnic Geotechnical laboratory of the soil sample taken at depth of 2m,the soil site is having the bearing capacity ,Pb= 320 KN/m^2.

3.10.1. Penetration test

The Penetration test is a common in situ testing method used to determine the geotechnical engineering properties of subsurface soils. This method is used to determine the soil bearing capacity and location of hard soil in depth, in order to check if the soil is capable to resist to the superstructure. The tool used is penetrometer (is an instrument for determining the consistency or hardness of a substance by measuring the depth or rate of penetration of a soil or needle driven into it by a known force).

3.10.2. Bearing capacity

Bearing capacity is the power of foundation soil to hold the forces from the superstructure without undergoing shear failure or excessive settlement. Foundation soil is that portion of ground, which is subjected to additional stresses when foundation and superstructure are constructed.

Bearing capacity, in geotechnical engineering, bearing capacity is the capacity of soil to support the loads applied to the ground. The bearing capacity of soil is the maximum average contact pressur*e* between the foundation and the soil, which should not produce shear failure in the soil.

The allowable bearing capacity (q_a) is the maximum bearing stress that can be applied to the foundation such that it is safe against instability due to shear failure and the maximum tolerable settlement is not exceeded. (Bowles, J.E, 1988)

The tables below show data taken at site with penetrometer instrument and it is used in allowable bearing capacity calculation.

According to Meyerhof, formula to calculate allowable bearing capacity is the following:

qa= $0.32*(\frac{N}{2})*RDf*(\frac{B+0.3}{B})^2*Sa$

Where; qa: is Allowable-bearing capacity

N: is number of blows

RDf: $1+0.33*(\frac{Df}{B})$, (is depth correction factor)

Df: is foundation depth

B: footing base (=1.5m)

Sa: Permissible settlement (= 20mm on multistory building)

Bearing capacity (qa) should be greater than column design load.

Allowable load = qa*A, where qa is allowable bearing capacity and A is footing cross section.

3.11. Building description and architectural design

3.11.1. Ground floor

Ground floor is constituted by:

- 4 Bedrooms
- 4 living rooms
- 4 dining rooms
- 4 bathrooms
- 4 verandah

3.11.2. First floor

Ground floor is constituted by:

- 4 Bedrooms
- 4 living rooms

- 4 dining rooms
- 4 bathrooms
- 4 verandah

3.11.3. Second floor

Ground floor is constituted by:

- 4 Bedrooms
- 4 living rooms
- 4 dining rooms
- 4 bathrooms
- 4 verandah

3.11.4. External works

The external works are contained by asphalt paving road parking, public lighting, entrance, security house, greenery and drainage pipe system

3.11.5.Constructive system of building and materials

The structure frame will be in reinforced concrete and the masonry in ordinary burnt bricks. The vertical loads are mainly resisted by frame system.

3.11.6. Architectural plans

The executions plans that define and detail the building are presented in this work. In this include beam and column reinforcement details and they are elaborated using certain software of architecture such as ArchiCAD and Artlantis.

ArchiCAD is the leading Building Information Modelling software application used by architects, designers, engineers and builders to professionally design, document and collaborate on building projects. This project drawings are drawn by using ArchiCAD software including; floors plan, sections, elevations and perspectives of structural building and details of structural building components as slabs, Beams, Columns, Foundations, Stairs and Ramp.

3.12. Analytical method

Analytical method is as set of techniques or critical calculation that allow to find dimensions and qualitative of any material which composite of any structural design elements. This method is applicable without any software, about this project; slabs, columns, foundations and stairs will design with helping analytical method.

- **Formula concern to the slab calculation**

Slab thickness determination, it values between $\frac{Lx}{30}$ and $\frac{Lx}{40}$

Total design ultimate load on the full width of panel between adjacent bay centre lines (= 1.4Gk + 1.6Qk).

- **Formula concern to the slab calculation**

Slab thickness determination, it values between: $\frac{Lx}{30}$ and $\frac{Lx}{40}$

Total design ultimate load on the full width of panel between adjacent bay centre lines (= 1.4Gk + 1.6Qk).

M_{RC} =0.156 $fcubd^2$

$$K = \frac{M}{fcubd^2}$$

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

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

- **Formula concern to the column calculation**

The effective height of the column is given by:

le=βlo

where le: effective height

β=coefficient used to determine effective height of the column

$0.75 < \beta < 1$

lo: clear height

$\frac{lex}{h}$<15:Short column and braced

$\frac{ley}{b}$<15: Short column and braced

$\frac{lex}{h}$<10:Short column and braced

$\frac{ley}{b}$<10: Short column and braced

The formula concern to the beam computation

The depth of the beam lies between;

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

The breath of the beam lies between;

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

$\mathbf{b_f}$ for T beam is equal to the smallest value of the following:

- $12h_f$ + bw
- A third of the span of the beam= $\frac{Span}{3}$
- A half of the distance between this beam and the nearest beam= $\frac{D}{2}$

3.13. Preliminary data

3.13.1. Standards used

The standards used to recover the section of the reinforcements of the different elements of construction of the building in question are the BS 8110 and BS 5950.

3.13.2. Materials' coefficients

For concrete γ_c =1.50

For steel γ_s =1.05

3.13.3. Units.

- Unit weight: KN/m^3

- Unit area: KN/m^2

- Linear load: KN/m

- Point load: KN

3.13.4. Values to be taken into account.

Self weights of the construction materials.

- Roofing made of sheet metal: 0.5KN/m^2
- False ceiling: 0.13KN/m^2
- Reinforced concrete: 24KN/m^3
- Finishing: 1.0KN/m^2
- Masonry in bricks: =18KN/m^3
- Plastering: 1KN/m^2
-Handrails: 0.1KN/m

Imposed loads.

According to the intended use of the complex and ‘‘Code of Practice; the live load is of 3KN /m^2, for apartment building.

Characteristic strength in compression of the concrete.

In all structural members we will use 25N/mm^2 as characteristic strength of the concrete.

Elastic limit

The reinforcements to be used will be of the type f_{yk}=460N/mm^2 for all the main reinforcements and f_{yk}=250N/mm^2 for stirrups.

3.14. Design information

Floor–Imposed load= 3 KN/m^2 (about apartment)
Self weight of Reinforced concrete= 24KN/m^3
Self weight of concrete = 20kN/m^3
Self weight of masonry = 19kN/m^3
Safety factor for dead load= 1.4
Safety factor for live load= 1.6

Steel resistance (Rs) = 40

3.15. Softwares

1. **Microsoft office word 2010**

The Microsoft word helped a lot within this project in the writing of this research.

2. **Microsoft office excel 2007**

The Microsoft offices excel helped a lot within this project in the writing of this research. Especially in tabulating tables.

3. **AutoCAD 2010:**

AutoCAD (Computer Aided Design or Computer Aided Drafting) software application for 2D and 3D design and drafting developed and sold by Autodesk.

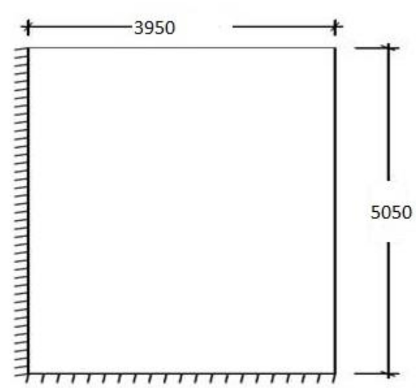
This software has been used in drawing different figures in this project.

4. **ArchiCAD 22**

AutoCAD (Computer Aided Design or Computer Aided Drafting) software application for 2D and 3D design and drafting developed and sold by Graphisoft.

This software has been used in drawing different figures in this project.

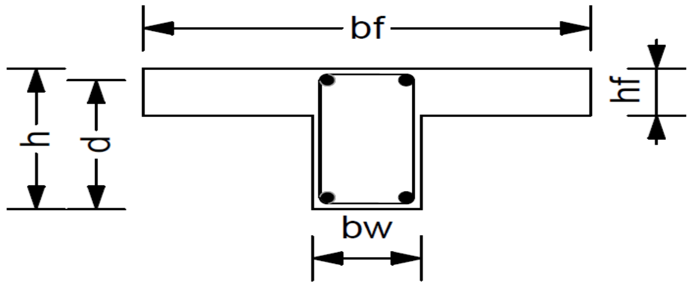
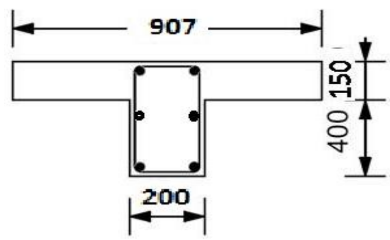
CHAPTER 4.RESULTS AND DISCUSSIONS

References	Description	outputs
See Critical Panel D-D&9-9 of structural plan	**4.1. Design of slab.** Slab is designed by considering critical panel of structural plan. **4.1.1. Critical Panel**  Figure 4.1: Two adjacent edge discontinuous critical panel.	
BS 6399-1 1996 Table 1 imposed load of apartment	**4.1.2. Pre-design** Live load=3KN/m^2 Main bars are 10mm of diameter. Cover:-mild :25mm -Exposure condition 2h:25mm Let's take 25mm	Live load=3KN/m^2
BS 8110-1:1997 Table 3.3 and table 3.4	Unit weight of RC =25 KN/m^3 Floor finishes = 1.8KN/m^3 Exposure condition, 1 hour Fcu=30N/mm^2 f_y =460 N/mm^2 b:1m=1000mm $\frac{lx}{d} = 26$, d = $\frac{\text{lx}}{2.6} = \frac{3.95}{26} = 151\text{mm} \approx 150\text{mm}$ lx/30 <L>lx/45 131<L>80mm Slab thickness =150mm Effective depth of the slab = h-cover -$\frac{\theta}{2}$ = 150-5-25=120mm	Slab thickness

	b:1m=1000mm	=150 mm
	$\frac{ly}{lx} = \frac{5.05}{3.95} = 1.28 < 2$. This is 2 ways slab	d=120mm
	N = 1.4Gk + 1.6Qk	
	Dead load :	Two way slab
	From slab = 0.2*25 = 5 KN/m^2	
	From finishes = 1.8KN/m^2	
	Total dead load =5 KN/m^2 + 1.8 KN/m^2 = 6.8KN/m^2	Total dead load= 6.8KN/m^2
	Imposed load	
	Minimum imposed load from the slab of apartment is 3KN/m^2	
	Total design load = 1.4*6.8 + 3*1.6 = 14.32 KN/m^2	Total design load = 14.32 KN/m^2
	4.1.3. Design for Shear and bending moment	
	Design for moment	
	Short span discontinuous edge	
BS8110-1Clause 3.5.3.4 Table 3.14 BS 8110-1,See appendix10	Mid span = Msx = $\beta_{sx}*Wl_x^2$	
	Support = Msy = $\beta_{sy}*Wl_y^2$	
	M^+=0.081*14.32*3.95^2 = 18.97KNm	
	Long span discontinuous edge	
Table 3.14 BS 8110-1,see appendix 10	M^+=0.056*14.32*5.05^2= 20.45KNm	
	Design for shear	
	Vsx= $B_{vx}nl_x$	
BS 8110-1, clause 3.5.3.7 Table 3.15 BS 8110-1,see appendix 11	Vsy =$B_{vy}nl_y$	
	Short span	
	Discontinuous edge: V_{sx}=0.41*14.32*3.95= 23.19KN	
	Long span	
Table 3.15 BS 8110-1,see appendix11	Discontinuous edge: V_{sy}=0.33*14.32*5.05= 23.86KN	
	Then we take maximum values for design which are:	
	Moment :20.45 KNm	M=20.45 KNm
	Shear :23.86 KN	V=23.86KN
	Analysis for Sagging moment	

	Moment = M = 20.45 KNm	
	M_{RC} =0.156 $fcubd^2$ = 0.156*30*1000*120^2 = 67.39 KNm	
	M_{RC} > M hence reinforcement in compression are not required.	No compression bars
BS 8110-1,clause 3.4.4.4	$K = \frac{M}{fcubd^2} = \frac{20.45*10^6}{30*1000*120^2} = 0.047 < 0.156\ ok$	K=0.047
BS 8110-1,clause 3.4.4.4	Z=120[0.5+(0.25 -0.047 /0.9)$^{1/2}$]≤0.95d	
	Z=101.18<114 ok	Z=101.18mm
	As=$\frac{M}{0.87fyz}$	
	As=$\frac{20.45*10^6}{0.87*460*101.18}$= 505.035 mm^2 ,	As prov= 505.035 mm^2
	Asprov.= 565mm^2 provide 5T12@ 200 c/c	
BS 8110-1,clause 3.12.5.3	Asmin =$\frac{100}{Ac} = 0.13$	
	Asmin =$\frac{1000*150*0.13}{100}$ = 195 mm^2 ,	As min prov = 195 mm^2
	As min prov =235mm^2 provide 3T10@ 250 c/c	
BS 8110-1,clause 3.12.6.1	As max=$\frac{4*1000*150}{100} = 6000\ mm^2$	
	4.1.4. Analysis for shear reinforcement	
	Maximum shear =23.86 KN	
BS 8110-1,clause 3.4.5.2	W =$\frac{v}{bd}$ V=$\frac{23.86*10^3}{1000*120} = 0.19 N/mm^2$	
BS 8110-1,clause 3.4.5.4	$W_c = \frac{0.79\left[\left(\frac{(100As)^{\frac{1}{3}}}{bd}\right)*\left(\frac{(400)^{\frac{1}{4}}}{d}\right)*\left(\frac{(fcu)^{\frac{1}{3}}}{25}\right)\right]}{1.25}$	
BS 8110-1,clause 3.5.7	$\left(\frac{100\times448}{1000\times120}\right)^{\frac{1}{3}} = 0.72 < 3$ ok	
	$(\frac{400}{120})^{1/4} = 1.23 > 1$ ok	
BS8110 Part 1-1997 table 3.9	$(\frac{30}{25})^{1/3} = 1.1$	
BS8110 Part1-1997 table 3.10	$W_c = \frac{0.79*0.72*1.23*1.1}{1.25} = 0.61 N/mm^2$	
	W<Wc	
	Hence the shear reinforcements are not required.	

BS 8110-1,clause 3.4.4.4 BS 8110-1,clause 3.4.4.4 BS 8110-1,clause 3.12.5.3 BS 8110-1,clause 3.12.6.1 BS 8110-1,clause 3.5.8 and BS 8110-2:1985	**4.1.5. Deflection check** Basic span/d=26 Modification factor M.F=$\frac{477-fs}{120(\frac{M}{bd}+0.9)} \leq 2$ **fs=**$\frac{2}{3}fy\frac{As}{Asprov}*\frac{1}{\beta}$ = **fs=** $\frac{2}{3}460\frac{505.039}{565}$ **= 274.11** $\frac{M}{bd^2}=\frac{20.45*10^6}{1000*120^2}=1.42$ $M_f=\frac{477-274.11}{120(0.9+1.42)}$ =0.72≤ 2 OK. **Allowable span/d=26*M_F = 26*0.72= 18.72** **Actual span=Span/d=$\frac{2150}{120}=17.9$ OK** **Allowable span is greater than Actual span** Hence the slab is safe from deflection. **4.1.6. Crack control** BS8110 states that the maximum spacing of bars in tension is given by 3d = 3x120mm = 360 mm. Since all the spacing is less than 360mm, there is no cracking. **4.2. Design of beam** **Pre-design** Width of the beam b_w = 200 mm Let take h = 550 mm The value of **h** is found after verification of the following condition: $\frac{L}{12} \leq h \leq \frac{L}{10}$ L = 5050 m ; $\frac{4.46}{12}=0.37 \leq h \leq \frac{4.46}{10}=0.44$ 5050/12 = 420 mm; 5050/10= 505mm	No shear reinforcement are required The slab is safe for deflection There is no cracking.

	Let take h = 550mm  	
BS 8110-1:1997, section 3,clause 3.4.1.5	$$bf = bw + \frac{lz}{5} = 200 + \frac{5050 * 0.7}{5} = 907mm$$	bf=907mm
	 Figure 4.2: Flanged T-beam for beam D-D fcu =30N/mm^2 fy = 460 N/mm^2 Height of the beam = 550mm	
BS8110-1 1997 Table 3.3 and Table 3.4 for cover	Cover:-mild :25mm -Exposure condition 2h:25mm Let's take 25mm	Cover=25mm
	Effective depth: -main bar = T16 -Link =T8 d=550-8-8-25=509 mm **Design for shear and bending moment**	d=509mm
	i. Dead loads calculation Dead load from masonry=0.2*2.85*20=11.4KN/m Dead load from finishes=0.03*2.85*22*2=3.762KN/m Dead load from plinth=0.03*0.15*22*2=0.198 KN/m Design load from slab = 0.2*25 KN/m^3+1.8 KN/m^2 = 6.8 KN/m^2	

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$P_1=\frac{wlx}{3}(\frac{3-m^2}{2})$ $m=\frac{lx}{ly}$ $m=\frac{3.95}{5.05}=0.78$
Where w is design load from slab

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

Imposed loads calculation

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

$P_1=\frac{3*3.95}{3}\left(\frac{3-0.78^2}{2}\right)=4.72KN/m$
Total dead load from slab = 11.4 KN/m + 3.762 KN/m + 0.198 KN/m 10.70 KN/m =26.06 KN/m
Total imposed load from slab = 4.72 KN/m

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

KN/m=44.036KN/m

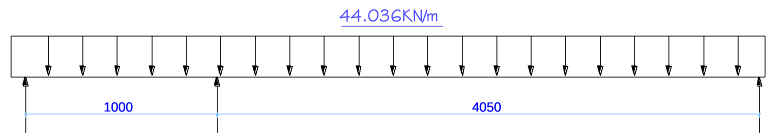

Figure 4.3: Loading diagram (KNm) of beam D-D

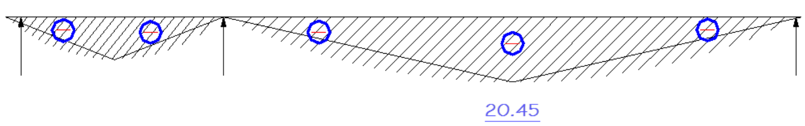

Figure 4.4: Bending moment diagram (KNm) of beam D-D

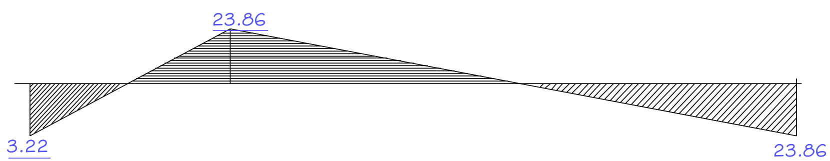

Figure 4.5: Shear force diagram (KN) of beam D-D

Design for sagging moment

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<td>Total design load on beam= 44.036 KN/m</td>
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	Sagging Moment=126.55KNm	
	$M_{RC}= 0.45fcubhf(d-\frac{hf}{2})$	
	$M_{RC}= 0.45*30*907*200\left(509-\frac{200}{2}\right) = 1001.6KNm$	
	M_{RC}>M, the neutral axis is in flange, so the beam will be designed as a rectangular beam	The beam will be designed as rectangular beam
BS 8110-1,clause 3.4.4.4	$M_{RC}= 0.156*30*1000*509^2$ = 1212.49KNm so $M<M_{RC}$	
	$K=\frac{M}{fcubd^2}=\frac{126.55*10^6}{30*1000*509^2}=0.016<0.156$, no compression bars are required	K=0.016
BS 8110-1,clause 3.4.4.4	Z= d [0.5+ (0.25- k /0.9)$^{1/2}$] ≥ 0.95d	
	Z= 509 [0.5+ (0.25- 0.016 /0.9)$^{1/2}$] = 499.78 > 483.55	
BS 8110-1,section 3.5.7	Let's take Z = 483.55mm	Z=483.55mm
	As= $\frac{M}{0.87fyz}=\frac{126.55*10^6}{0.87*460*483.55}=653.95mm^2$	
	As min=$\frac{0.3*1000*550}{100}=1650mm^2$	
	As max=$\frac{4*1000*550}{100}=22000mm^2$ ok	
	As provided = 1884 mm^2 provide 6T20	As prov = 1884 mm^2
	Deflection check	
BS8110 Part1-1997 table 3.9	Span/6=26	
	Modification factor (M.F)	
BS8110 Part1-1997 table 3.10	M.F= $0.55+\frac{477-fs}{120(\frac{M}{bd^2}+0.9)} \leq 2$	
	fs=$\frac{2}{3}fy\frac{Asrequired}{Asprovided}*\frac{1}{\beta}$ fs=$\frac{2}{3}460\frac{1650}{1884}$ *1=268.5	
	$\frac{M}{bd^2}=\frac{126.55*106}{200*509^2}=2.44$	
BS 8110-1,clause 3.4.5.2	M.F= $0.55+\frac{477-268.5}{120(2.44+0.9)}$ =0.52<2 ok.	
	Allowable span/d=26*M.F =26*0.52=13.52	
	Actual span/d=5050/509 = 9.92<13.52	The beam is

Allowable span/d is greater than Actual span/d

Hence there is no deflection.

Shear design

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

BS 8110-1,clause 3.4.5.4

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

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

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

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

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

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

W<Wc

Therefore shear reinforcement bar are not required

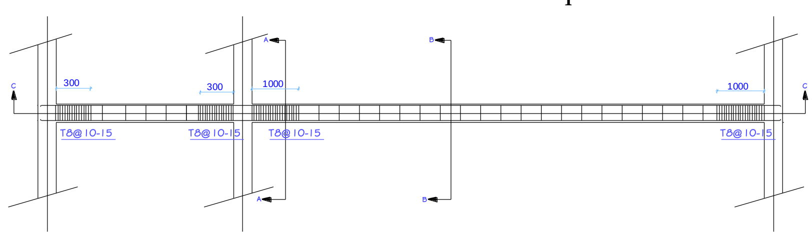


Figure 4.6: Reinforcement layout in beam

4.3.Design of a column

The column is designed by considering the load taken down on the heavy loaded column by using influence area method. The loads taken down are shown on appendix 7 and the influence area is shown in appendix 8.

Specifications

-Height= 2.850m

-Section=200mm*200mm

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

-f_y= $460/mm^2$

safe for deflection

Shear reinforcement are not required

Vx = 111.19 KN

V=0.2 N/mm^2 ok

d = 509

2d=1018mm

Asprov=100mm^2

Sv=173mm

	-Thickness of finishing= 30mm -Imposed load=3KN/m^2 -Unit weight of finishing=$22KN/m^2$ -Unit weight of masonry=20 KN/m^3	Imposed load=3KN/m^2
BS 8110,clause 3.8.1.3	**Check for slenderness of column** The effective height of the column is given by: le=βlo where: le: effective height β=coefficient used to determine effective height of the column 0.75< β<1 lo: clear height β=(0.75+1)/2=0.85 $$le = 0.85 * 2.85 = 2.42m$$ $$\frac{le}{h} = \frac{2.42}{0.2} = 12.1$$ $$\frac{le}{b} = \frac{2.42}{0.2} = 12.1$$	
BS 8110-1,clause 3.8.1.3	Since the ratios above are less than 15, we have the short unbraced column. Therefore the column will be designed as short unbraced column.	The column will be designed as Short column
	Finding moment (M), shear force and Reactions Reaction from beam 19-19= 516.52KN Reaction from beam D-D= 279.24KN $h'=d = h - cover - \frac{\Phi main\ bars}{2}$ $$h' = 200 - 25 - 8 - \frac{16}{2} = 159mm$$ $$b' = 200 - 25 - 8 - \frac{16}{2} = 159mm$$	$h' = 159mm$ $b' = 159mm$
	Column moments calculation in y-direction $K_{AB}=\frac{1}{2} * \frac{bh^3}{12L_{AB}}=\frac{1}{2} * \frac{0.2*0.55^3}{12*5.05}= 5.49*10^{-4}$ $K_{CD}=\frac{0.2^4}{12*2.85}=4.67 * 10^{-5}$ εK=$K_{AB} + K_{col}=5.49 * 10^{-4} + 4.67 * 10^{-5}$ =$5.95*10^{-4}$	Distribution

	Distribution factor for the column= $\frac{K_{col}}{\epsilon K}=\frac{4.67*10^{-5}}{5.95*10-4}$=0.078 **Fixed end moment at B** F.E.M_{BA}=$\frac{qL^2}{12}$=$\frac{\mathbf{936.8941}*5.05^2}{12}$=1991.094KNm Difference of moments=1991.094KNm Column design moment= 1991.094KNm * 0.078= 155.305 KNm **Column moments in X-direction** **Stiffness calculation**: $K_{AB}=\frac{1}{2}\times\frac{b.h^3}{12\times L_{AB}}=\frac{1}{2}\times\frac{0.2\times 0.55^3}{12\times 4.05}=3.42\times 10^{-4}$ $K_{BC}=\frac{1}{2}\times\frac{b.h^3}{12\times L_{BC}}=\frac{1}{2}\times\frac{0.2\times 0.55^3}{12\times 2.25}=6.16\times 10^{-4}$ $K_{Col}=\frac{0.2^4}{12\times 2.85}=4.67*10^{-5}$ $\varepsilon K=3.42\times 10^{-4}+6.16\times 10^{-4}+4.67*10^{-5}$ =0.0010047 Distribution factor = $\frac{K_{Col}}{\varepsilon K}=\frac{4.67*10^{-5}}{0.0010047}=0.046$ **Fixed end moment at B:** F.E.$M_{AB}=\frac{q.L^2}{12}=\frac{\mathbf{936.8941}\times 4.05^2}{12}=1280.6171KNm$ F.E.$M_{BC}=\frac{q.L^2}{12}=\frac{621.8615\times 2.25^2}{12}=262.3478KNm$ Difference of moments = $1280.6171KNm-262.3478KNm=$ $1018.2692KNm$ Column design moment =$1018.2692KNm\ \times 0.046=$ $46.84KNm$ My=155.305 KNm Mx=46.84 KNm $h'=h-cover-\frac{16}{2}-\emptyset link=319mm$ $h'=200-25-8-\frac{16}{2}=159mm$ $b'=200-25-8-\frac{16}{2}=159mm$ if	factor =0.078 Column design moment in y direction= My = 155.305 KNm Distribution factor=0.046 Column design moment in x-direction=Mx= $46.84KNm$ $h'=319mm$ $b'=319mm$

	$$\frac{My}{b'} > \frac{Mx}{h'}$$	
	$$\frac{155.305}{0.159} > \frac{46.84}{0.159}$$	
BS 8110-1,clause 3.8.4.5	Then the increased single axis design moment is: $$M'y = My + \beta.\frac{b'}{h'} \times Mx$$	
BS 8110-1,table 3.22	β is specified in table 3.22 BS 8110 by considering $\frac{N}{b.h.fcu}$: $$\frac{N}{b.h.fcu} = \frac{\mathbf{936.8941} \times 10^3}{200 \times 200 \times 30} = 0.78$$	$\beta = 0.3$
BS 8110-1,clause 3.8.1.2	$$\beta = 0.3$$	$M'y = 169.357$KNm
	$M'y = 155.305 + 0.3\frac{159}{159} \times 46.84 = 169.357$ KNm	
BS 8110-1,clause 3.8.1.6.1	$$\frac{N}{b.h} = \frac{936.8941 \times 10^3}{200 \times 200} = 23.42N/mm^2$$	
	$$\frac{M}{b.h^2} = \frac{169.357 \times 10^6}{200 \times 200^2} = 21.169$$	
BS 8110-1:1985,chart No.29	$$\frac{d}{h} = \frac{159}{200} = 0.8$$	
	$$\frac{100.Asc}{b.h} = 5.6$$	Asc $= 2240\text{mm}^2$
	$$Asc = \frac{1.2 \times b \times h}{100} = \frac{5.6 \times 200 \times 200}{100} = 2240mm^2$$	
	$$Ascmin = 0.004.b.h = 0.004 \times 200 \times 200 = 160mm^2$$	
	$$Ascmax = 0.06.b.h = 0.06 \times 200 \times 200 = 2400mm^2$$	
	$$Ascmin < Asc < Ascmax$$	Asprov $= 2454\text{mm}^2$
	$160mm^2 < 2240mm^2 < 2400mm^2$ the area is satisfactory	
	$Asprov = 2454mm^2$ provide 5T25@120 c/c	
	Shear reinforcement	
	BS 8110 states that the diameter of ring $\emptyset\ ring$ is equal to ¼ of the bigger longitudinal bar and this must be greater or equal to 6mm	There is no cracking in the column Ring

Mosley,R.hulse,1996

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

diameter=8mm

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

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

Spacing=300mm

Reinforcement in column:

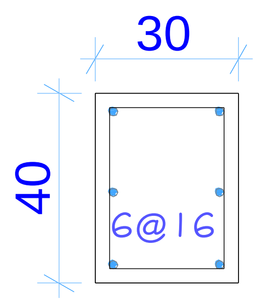


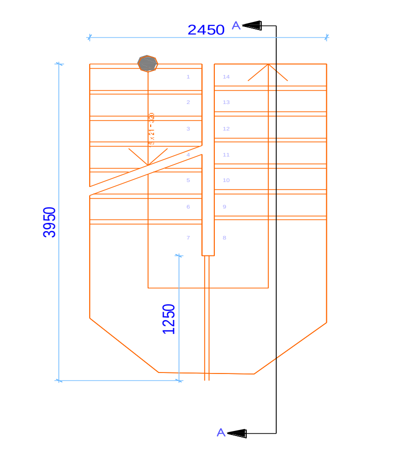
Figure 4.7: Reinforcement layout for column

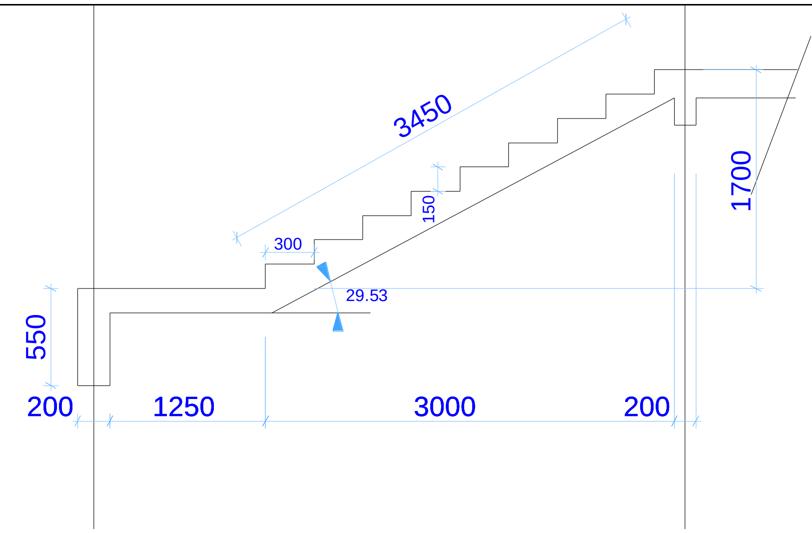
3 types of columns as it is shown on the structure details:

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

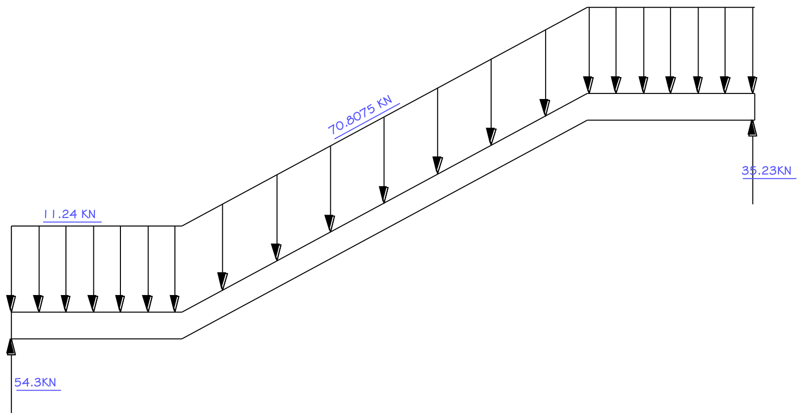
Mosley,R.hulse,1996

4.4.Design of stair

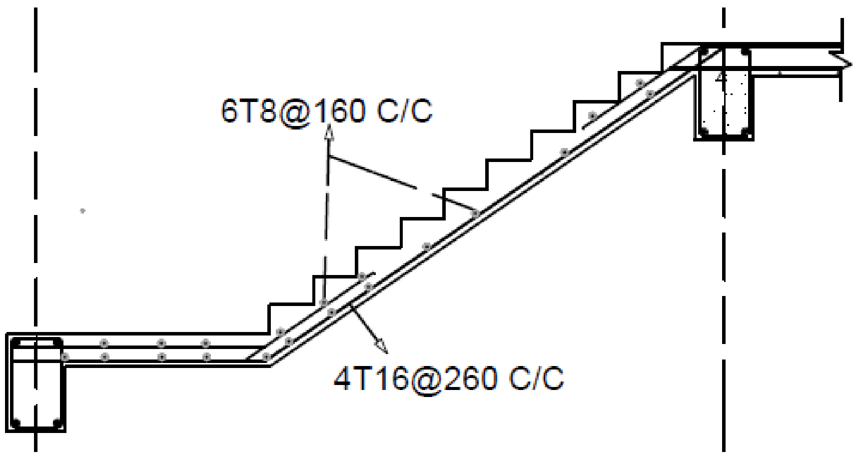


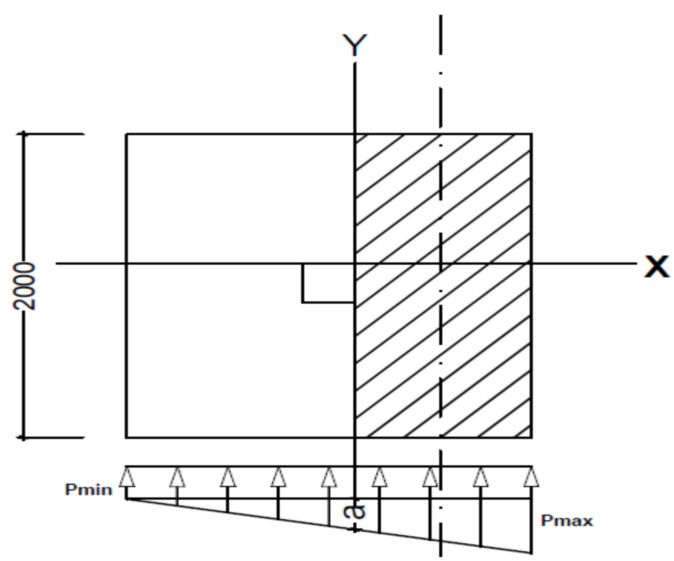
Mosley,R.hulse,1996	 Figure 4.8: Plan view and section of public stair to be designed and its section	
	Specification	
	fcu = 30N/mm^2	
	fy = 460 N/mm^2	
	$\varnothing$Main bars: 10mm	
	Cover = 25mm	
	Unit weight of concrete = 25N/m^3	Riser = $150mm$
	Imposed load=1.5KN/ mm^2	Going(tread)= $300mm$
	Finishers unit weight=22KN/ m^3	
	Riser = $150mm$	Effective span=3.00m
	Going (tread)= $300mm$	
Mosley,R.hulse,1996	Pitch $\leq 38°$	
	Number of steps in flight≤ 18	
	$$700mm > G + 2R > 550mm$$	
	$700mm > 300mm + 2 * 150mm > 550mm$ ok	
	Number of risers = Number of goings +1=9+1=10 risers	
	The stair landing slab has 15mm of plaster finish underside and at the top	Height of waist=170mm
	Effective span = $la + 0.5(l_{b1} + l_{b2})$ =4.15+0.5(0.2+0.2)=4.35m	
	Depth of waist = $\frac{4350mm}{26} = 167mm$	Stair

	Height of waist is equal to the thickness of slab take height=150mm Stair slope= tan$^{-1}\frac{1.7}{3} = 29.53^{o}$ Horizontal distance=4150mm-1250mm+200mm/2=3000mm=3m Slope distance = $\sqrt{(1.7)^2+(3)^2} = 3.45m$ **Load calculation** **Load from landing** The thickness of slab including the top and bottom side finish equal to 150 mm Dead load = $0.15 \times 25 \times 1.4 = 5.25KN/m^2$ Imposed load = $1.5 \times 1.6 = 2.4KN/m^2$ Total load=5.25 KN/m^2+2.4 KN/m^2=7.65KN/m^2 Applied load from landing slab =7.65$KN/m^2 * 0.5(1.250)1.200m^2 = 5.7375KN$	slope=29.53^0 Slope length=3.45m Applied load from landing slab=5.74KN
BS 8110-1,clause 3.10.1.1 and clause 3.10.1.2 BS 8110-1, clause 3.10.1.1 and clause 3.10.1.2 stair loading distribution.	One half of the load on the landing slab is included for the stair slab under consideration. The loaded width is 1900mm **Stair slab loading** The average thickness including finishes is: $150 + \frac{148}{2} = 224mm$ Dead load $= 0.224 \times 25 \times 3.45 \times 1.4 \times 1.9 = 51.39KN$ Imposed load $= 1.5 \times 3 \times 1.9 \times 1.6 = 13.68KN$ Total load$= 51.39KN + 13.68KN = 65.07KN$ The dead load while imposed load acts on the span length is calculated by using the slope length The total load on span length=5.7375 KN+65.07KN=70.8075KN	Total load=65.07KN The total load on span length=70.80KN

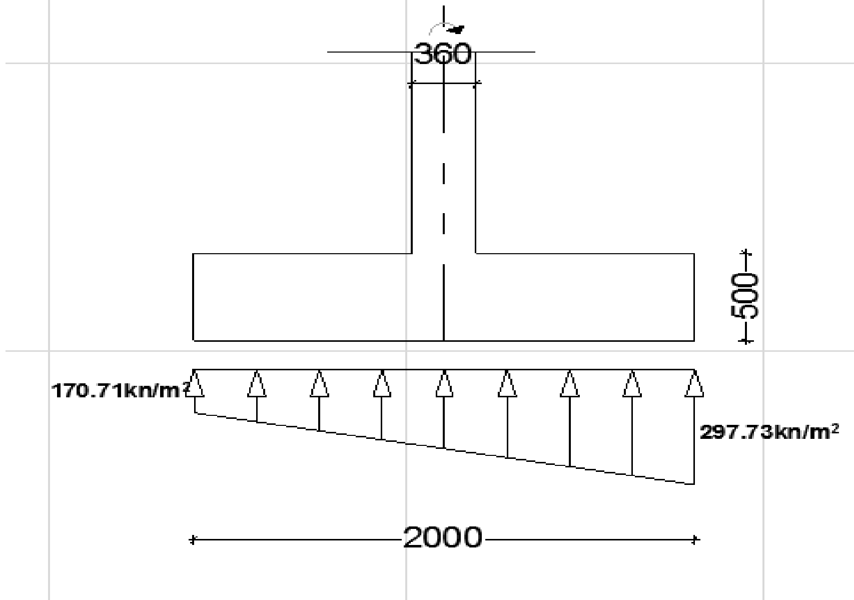
BS 8110-1, clause 3.10.1.1 and clause 3.10.1.2 stair loading distribution	 Figure 4.9: Loading of stair- slab and its bending moment diagram and shear force diagram	
	Design for moment and shear a. **Design for moment** Support and mid span=$\frac{WL}{10} = \frac{70.8075KN*4.35m}{10} = 30.80KNm$	M=$30.8KNm$
	Design shear RA+RB=70.8075KN $\varepsilon MA = 4.35RB - 5.7375 \times 0.725 - 65.07 \times 3.35$=0 $= 4.35RB - 222.144$=0 $$R_B = \frac{222.144}{4.35} = 51.06KN$$ $$R_A = 70.8075KN - 51.06KN = 19.73KN$$	Maximum shear force = 51.06KN
	Maximum shear force equal to 51.06 KN **Moment reinforcement** Effective depth d is $150 - \frac{10}{2} - 25 = 120mm$	Effective depth=120mm
BS 6399-1:1996	$b = 1200mm$ is the width of the stair $\frac{M}{b.d^2} = \frac{30.8\times10^6}{1200\times120^2}$=1.78	
	$$\frac{100 \times As}{b.d} = 0.4$$ $$0.24bd = 100.As$$	$As = 576mm^2$ $As\ prov =$

	$$As = \frac{0.4 \times 1200 \times 120}{100} = 576mm^2$$ $As\ prov = 628mm^2$ for 8T10@120 C/C The minimum area of reinforcement: Asmin=$\frac{0.13*150*1000}{100} = 195mm^2$	$628mm^2$ As min prov= 195 mm^2
Fig.4.13 reinforced concrete design theory,TJ MACGINLEY and BS CHOO	**Shear reinforcement design:** Maximum shear = 51.06 KN $$w = \frac{v}{b.d} = \frac{51.06 \times 10^3}{1200 \times 120} = 0.35N/mm^2$$	
BS 8110-1:1997,clause 3.4.5.2	$$wc = \frac{0.79(\frac{100 \times 628}{b.d})^{1/3}(\frac{400}{d})^{1/4}(\frac{fcu}{25})^{1/3}}{1.25}$$ $$\left(\frac{100 \times 628}{1200 \times 120}\right)^{\frac{1}{3}} = 0.75 < 3$$	
BS 8110-1:1997,clause 3.4.5.4	$$(\frac{400}{120})^{1/4} = 1.35$$ $$(\frac{30}{25})^{1/3} = 1.1$$ $$wc = \frac{0.79 \times 0.75 \times 1.35 \times 1.1}{1.25} = 0.7N/mm^2$$ $$wc > w$$ $$0.7N/mm^2 > 0.35N/mm^2$$ No shear reinforcement required	No shear reinforcement required
BS 8110-1,section 3.5.7	**Deflection check** Actual span/d ratio should be greater than allowable span	
BS 8110-1:1997,table 3.9	Basic span/d ratio = 26 $$fs = \frac{2}{3} \times fy \times \frac{Asreq}{Asprov}$$ $$fs = \frac{2}{3} \times 460 \times \frac{576}{628} \times 1 = 281.27\ N/mm^2$$ $$\frac{M}{b.d^2} = \frac{30.08 \times 10^6}{1200 \times 120^2} = 1.74$$	

BS 8110-1:1997,table 3.10	Modification factor(Mf): $$Mf = 0.55 + \frac{477 - fs}{120(0.9 + \frac{M}{b.d^2})} \leq 2$$ $Mf = 0.55 + \frac{477-281.27}{120(0.9+1.74)} = 1.16 \leq 2$ ok Allowable span = 1.16 × 26 = 30.16 Actual span/d = $\frac{\text{effective span}}{d} = \frac{4350}{120} = 28.3$ Since actual span/d = 28.3 is less than allowable span/d = 30.16 The stair is satisfactory with respect to deflection.  Figure 4.10: Reinforcement layout of stair slab	The stair is safe for deflection
ULK PEC Geotechnical &Concrete laboratory	**4.5. Design of foundation** **Design of pad foundation** **Specifications and data** The Bearing capacity taken in consideration for our soil is Pb =320KN/m^2 got from National Laboratory for similar building constructed in the area. fcu = 35N/mm^2 fy = 460N/mm^2 Total load on the column= 663.2915 KN Design load from the column N = 936.8941KN	Pb =320 KN/ m^2
BS 8110-		

1,clause 3.11.2	Design load from footing= *1.4Gk+1.6Qk +W* $$1.4Gk+1.6Qk=936.894KN$$ The self-weight of the isolated pad foundation (w) is between 10% and 20% of the design load of the column W=$\frac{936.894KN*15}{100}=140.5341KN$ **Procedures and design `** Service Load (Nd)= 140.5341KN+936.8941KN =1077.4282 KN Design moment from column=169.357 KNm Design moment applied on foundation=$\frac{169.357KNm}{2}=$ $84.6785KNm$	Service Load (Nd) = 1077.42KN Design moment= 169.35KNm
Reinforced concrete design theory,TJ MACGINLEY and BS CHOO; eccentrically loaded footing	Area of the pad foundation : $\frac{Nd}{Pb}=\frac{1077.4282\ KN}{320KN/m^2}=3.367\text{m}^2$ Dimension : $lx\ and\ ly=(Nd/Pb)^{\frac{1}{2}}=(3.367)^{\frac{1}{2}}=1.8m\approx 2m$ Let take a square footing of $2m\times 2m$ sides Design bearing pressure: $$lx=2m\ and\ ly=2m$$ $$e=\frac{M}{P+W}=\frac{169.357KNm}{803.8256}=0.2m$$ $\frac{L}{6}=\frac{2}{6}=0.3m>0.2m$ ok	Dimensions of the footing=2*2m e=0.2 m
Reinforced concrete design theory,TJ MACGINLEY and BS CHOO; eccentrically loaded footing	 Figure 4.11: Maximum and minimum pressure	Pmax= 264.46 $KN/$

	Pmax= $\frac{P+W}{A}+\frac{M+h}{Z}$ $\quad$ $, where\ Z=\frac{b.l^2}{6}$ Pmax= $\frac{803.8256}{2X2}+\frac{84.6785}{\frac{2X2^2}{6}}=200.9564+63.51=264.46\text{KN}/\text{m}^2$ Pmax $<$ Pb(bearing capacity) Safe Pmin= $\frac{P+W}{A}-\frac{M+h}{Z}$ $$\text{Pmin}=\frac{803.8256}{2X2}-\frac{84.6785}{\frac{2X2^2}{6}}=200.9564-63.51$$ $=137.45\text{KN/m}^2$ $137.45\text{KN/m}^2>0$ Safe So, the soil will carry the load safely. **4.5.3. Design to serviceability limit state**	m^2 $\text{Pmin}=137.45\text{KN}/\text{m}^2$ The soil is safe with respect to the footing
BS 8110-1,clause 3.11.3.1	**Maximum and minimum pressure** Design moment applied on footing =84.6785KNm Design load ignoring the self-weight of footing = 936.8941KN KN $P_{max}=\frac{936.8941}{2*2}+\frac{84.6785}{\frac{2*2^2}{6}}=234.22\frac{KN}{m^2}+63.51KN/m^2$=297.73KN/m^2 Pmin= $\frac{P+W}{A}-\frac{M+h}{Z}$ Pmin= 234.22KN/m^2-63.51KN/m^2= 170.71KN/m^2	Pmax=234.22 KN/m^2 Pmin= 170.71KN/m^2



Design moment

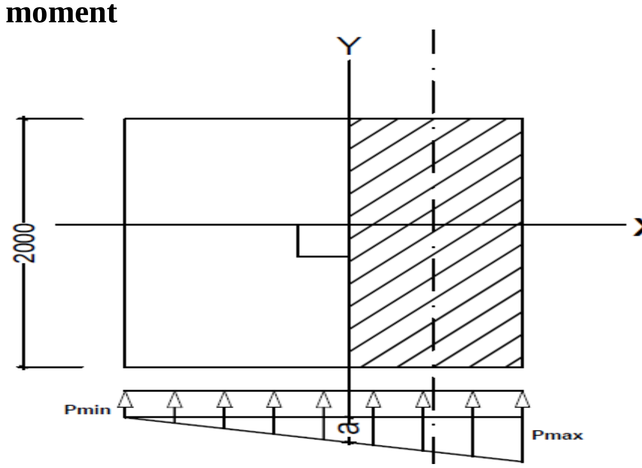


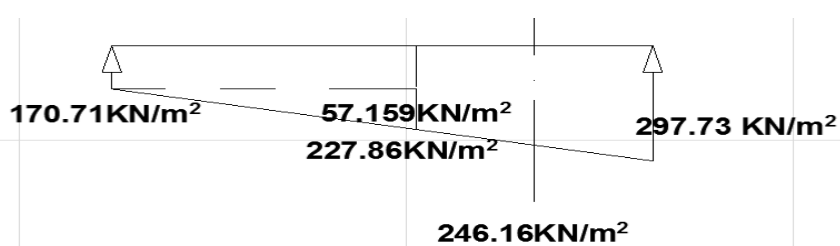
Figure 4.12: Diagram shows where to find moment of foundation

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

$$a = 57.159\text{KN/m}^2$$

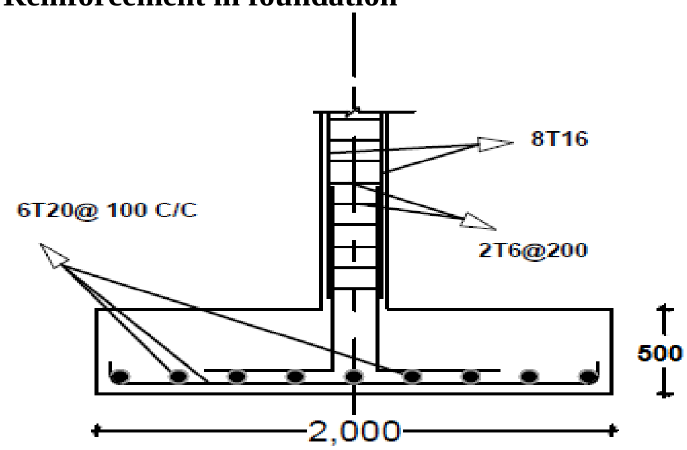
Maximum pressure= $\frac{170.71\text{KN}}{\text{m}^2} + \text{KN/m}^2$ + 57.159KN/m^2

=227.869KN/m^2



Average pressure= 511.5KN/m^2

	Figure 4.13: Diagram shows maximum pressure and average pressure where to find moment of foundation	My = 184.573
	As Lx = Ly maximum moment will be the same in both axis	
	$$My = 2\left[2-\left(\frac{2+0.2}{2}\right)\right]227.869 \times [\frac{2}{2}-(\frac{2+0.2}{4})]$$	Effective depth= 415 mm
	$$= 184.57389KNm$$	
	The thickness of the footing $=\frac{2+0.2}{4} = 0.55m = 0.6m$	
	Steel reinforcement in $y - y\ direction$:	
	$$fcu = 35Nmm^2$$	
	$$fy = 460Nmm^2$$	
	Cover = 75mm	
	Diameter of reinforcement: $\emptyset = 20mm$	
	Assume overall depth = 500mm	
	Effective depth = $d = h - c - \frac{\emptyset}{2}$	K=0.015
BS 8110-1,clause 3.4.4.4	$$d = 500 - 75 - \frac{20}{2} = 415mm$$	
BS 8110-1,clause 3.4.4.4	$$K = \frac{M}{fcu.b.d^2} = \frac{184.57389 \times 10^6}{35 \times 2000 \times 415^2} = 0.015 < 0.156 \quad ok$$	
	No compression bars are required	
	$z = d[0.5 + (0.25 - \frac{K}{0.9})^{1/2}] \leq 0.95d$	
	$z = d\left[0.5 + \left(0.25 - \frac{0.015}{0.9}\right)^{1/2}\right] \leq 0.95d$	Z=394.25mm
	$$z = 407.96mm$$	
	Take $z = 0.95d$	
	$$z = 0.95 \times 415 = 394.25mm$$	
	$$As = \frac{M}{0.87.fy.z} = \frac{184.57389 \times 10^6}{0.87 \times 460 \times 394.25} = 1169.83mm^2$$	
BS 8110-1,clause 3.12.5.3	As prov $= 1206mm^2$ provide 6T16@100 c/c	
BS 8110-1,clause 3.12.6.1	$$As\ min = \frac{0.13 \times b \times d}{100} = \frac{0.13 \times 2000 \times 415}{100} = 1079.mm^2$$	the area is satisfactory
	$$As\ max = \frac{0.4 \times b \times d}{100} = \frac{0.4 \times 2000 \times 415}{100} = 3320mm^2$$	

BS 8110-1,clause 3.11.3.2	As min $< As < Asmax$ $1079\text{mm}^2 < 1169.83mm^2 < 3320mm^2$ the area is satisfactory **Distribution steel** $\frac{3C}{4} + \frac{9d}{4} = \frac{3*200}{4} + \frac{9*415}{4} = 150 + 933.75 = 1083.75\text{mm}$ with C: column width d:effecive depth slab Lc= the spacing between column centers to the one of edge So $Lc = 1$ $Lc < \frac{3C}{4} + \frac{9d}{4} \leftrightarrow 1 < 1.083$ The reinforcement will be distributed uniformly **Reinforcement in foundation**  Figure 4.14: Reinforcement layout in foundation **Vertical shear**	The reinforcement will be distributed uniformly

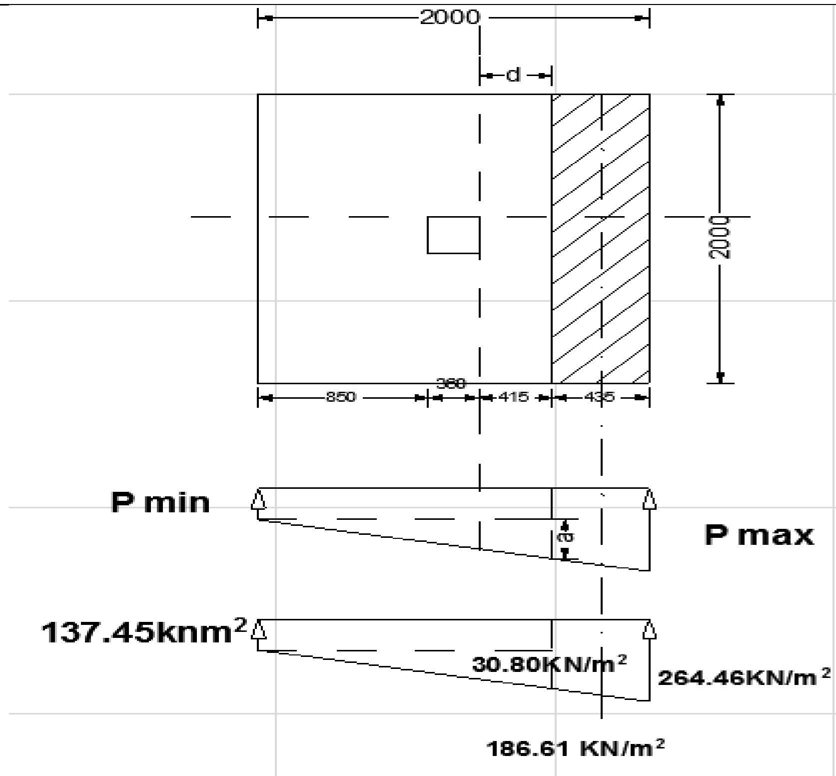


Figure 4.15: Vertical shear diagram

BS 8110-1,clause 3.11.3.3

$$d = 415mm$$

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

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

$$\frac{a}{297.73-170.71} = \frac{\frac{2}{2}-\frac{0.2}{2}-0.415}{2} =$$

$$a = 30.80KN/m^2$$

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

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

Average pressure= 186.11KN/m²

Reinforced concrete design theory,TJ MACGINLEY and BS CHOO; eccentrically loaded footing

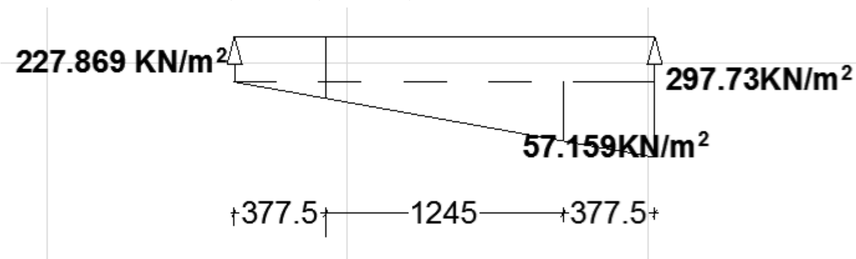
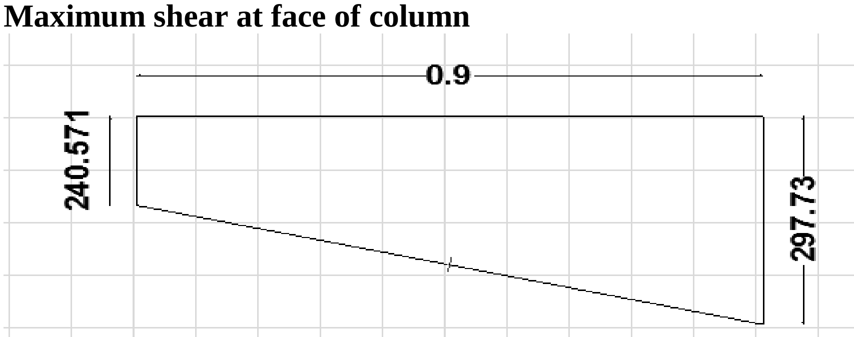
Area $= 2 * 0.485 * 186.11 = 180.53KN$

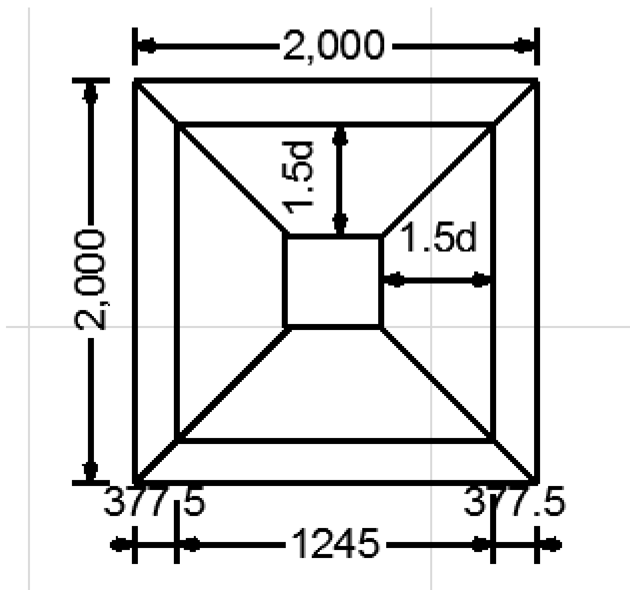
Vertical shear check:

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

$$w = \frac{180.53 \times 10^3}{2000 \times 415} = 0.217N/mm^2$$

Shear reinforcement are not required

BS 8110-1,clause 3.11.4.5 BS 8110-1,clause 3.11.4.5 BS 8110-1,clause 3.11.4.5	$wc=\frac{0.79(\frac{100\times Asp}{b.d})^{1/3}(\frac{fcu}{25})^{1/3}}{1.25}*(\frac{400}{d})^{1/4}$ $wc=\frac{0.79(\frac{100\times1256}{2000*415})^{1/3}(\frac{35}{25})^{1/3}(\frac{400}{d})^{1/4}}{1.25}$=0.37 N/mm^2 W<Wc therefore there are no shear reinforcement required **Punching shear force** $\frac{a}{297.73-170.71}=\frac{\frac{2}{2}-\frac{0.2}{2}}{2}$, $a=57.159\text{KN/m}^2$ Total pressure=57.159KN/m^2+170.71KN/m^2=227.869 KN/m^2 Total area=2*227.869*0.9=410.16 KN  Figure 4.16: Punching shear diagram $W=\frac{V}{permiter*d}=\frac{410.16*10^3}{1245*4*415}=0.198N/mm^2$ $wc=\frac{0.79(\frac{100\times Asp}{b.d})^{1/3}(\frac{fcu}{25})^{1/3}(\frac{400}{d})^{1/4}}{1.25}$= $wc=\frac{0.79(\frac{100\times1256}{2000*415})^{1/3}(\frac{35}{25})^{1/3}(\frac{400}{415})^{1/4}}{1.25}$=0.9 N/mm^2 W<Wc therefore there are no shear reinforcement required **Maximum shear at face of column**  Figure 4.17: Maximum shear diagram at face of the column	Total shear=289.4 KN No shear reinforcement required Maximum shear check is satisfactory

	$$\frac{a}{2-0.9}=\frac{127.02}{2}$$ $a=\frac{1.1*127.02}{2}=69.861\text{KN/m}^2$ $$V=\frac{240.571+297.73}{2}*0.9*2=484.47KN$$ $W=\frac{484.47*10^3}{2000*415}=0.58\text{N/mm}^2<\begin{cases}0.8fcu^{1/2}\\5N/\text{mm}^2\end{cases}$ $0.58\text{N/mm}^2<5N/\text{mm}^2$ **Punching at (1.5d)**  Figure 4.18: Punching shear diagram at 1.5d $$\frac{a}{2-0.2775}=\frac{127.02}{2}$$ $a=\frac{1.7225*127.02}{2}=109.4\text{KN/m}^2$ $$V=\frac{280.11+297.73}{2}+\frac{2+1.445}{2}*0.2775=289.4KN$$ $W=\frac{289.4*10^3}{1445*415}=0.48\text{N/mm}^2<\begin{cases}0.8fcu^{1/2}\\5N\text{mm}^2\end{cases}$ $0.48\text{N/mm}^2<5N\text{mm}^2$ Punching shear check is satisfactory	Punching shear check is satisfactory

	4.5.3.Crack check Because the area of steel does not exceed 0.3% of the area of foundation, there is no need of crack check. $$\frac{0.3}{100} * 2000 * 500 = 3000\ mm^2$$ As= $3000mm^2$ >1169.83 mm^2 The bar spacing not exceed 750mm or 3d : Spacing= $\frac{b-2cover-n*\emptyset MB}{n-1} = \frac{2000-150-16*6}{5} = 350.8mm$ $$3d = 3 * 415mm = 1245mm\ ok$$ $350.8mm < 1245mm$ Cracking check is satisfactory.	Cracking check is satisfactory

4.6. Results presentation for the reinforcements for each structural element

	ELEMENTS	MATERIALS			
		CONCRETE	STEEL		
			Longitudinal steel	Transversal steel	Discussions
1	Slab	fcu=30N/mm^2	5T12@200 C/C	3T10 @250 C/C	The minimum reinforcement bars of steel slab is 5 bars/condition is verified
2	Beam	fcu=30N/mm^2	6T20@120 C/C 7T16@120 C/C	2T8@173 C/C 2T8@273 C/C 2T8@280 C/C	
3	Column	fcu=30N/mm^2	5T25	T8@200 C/C	The minimum reinforcement bars of RC column is 12ø .condition is verified
4	Stair	fcu=30N/mm^2	8T10@260C/C	6T8@160 C/C	
5	Foundation	fcu=35N/mm^2	6T16@100 C/C	6T16 @ 100 C/C	

CHAPTER 5 . CONCLUSION AND RECOMMANDATIONS

5.1. Conclusion

This project had an objective of designing of residential apartment which is able to serve and to receive population needs.

The design of dead load, imposed load and wind load was achieved by determining the characteristic strength of materials must be respected during implementation.

.At the end of this proposed project, the objective was attained. Reinforced concrete structure was dimensioned, the specific steel bars required for stability of structures were calculated and architecture drawing of structure was produced, so it will resist the loading with in limit state.

The objective was attained by using different books and codes of practices and software like proton, the analysis of every structural member starting with the evaluation of all loads that are expected to be carried by the structure including its self-weight and also the collaboration with supervisor of this proposed project and with these, the British standard helped a lot to determine the satisfactory dimensions and reinforcements of structural members.

The project work enables the researchers to consolidate the knowledge of analysis and design of structure during bachelor's degree course.

Practically the soil stratum will be able to resist to upper applied loads due to that the bearing capacity of soil is greater than the pressure from the upper structure.

Design and layout of the building services like pipeline, sanitary and security camera were not covered in this project. The environmental, social and economic condition of the locality was not taken into consideration.

The project work was only related with the practical application of the studied courses in the field and Detail cost estimate of the project was included in this report.

5.2. Recommendations

After completion of this important project it is hereby observed that some spaces could have been designed in a better manner. Some spaces were not designed due to shortage of space or time constraints. During this project some features were not taken into consideration like electrical plan, green space plan, security camera, mass plan and mechanical plan.

The shortcomings could be overcome by further research and more showing great attention to detailed work by other researchers.

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APPENDICES

Appendix 1) Bending moment coefficient for rectangular panels supported on four sides with provision for torsion at corners

Table 3.14 — Bending moment coefficients for rectangular panels supported on four sides with provision for torsion at corners

Type of panel and moments considered	Short span coefficients, β_{sx}								Long span coefficients, β_{sy} for all values of l_y/l_x
	Values of l_y/l_x								
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
Interior panels									
Negative moment at continuous edge	0.031	0.037	0.042	0.046	0.050	0.053	0.059	0.063	0.032
Positive moment at mid-span	0.024	0.028	0.032	0.035	0.037	0.040	0.044	0.048	0.024
One short edge discontinuous									
Negative moment at continuous edge	0.039	0.044	0.048	0.052	0.055	0.058	0.063	0.067	0.037
Positive moment at mid-span	0.029	0.033	0.036	0.039	0.041	0.043	0.047	0.050	0.028
One long edge discontinuous									
Negative moment at continuous edge	0.039	0.049	0.056	0.062	0.068	0.073	0.082	0.089	0.037
Positive moment at mid-span	0.030	0.036	0.042	0.047	0.051	0.055	0.062	0.067	0.028
Two adjacent edges discontinuous									
Negative moment at continuous edge	0.047	0.056	0.063	0.069	0.074	0.078	0.087	0.093	0.045
Positive moment at mid-span	0.036	0.042	0.047	0.051	0.055	0.059	0.065	0.070	0.034
Two short edges discontinuous									
Negative moment at continuous edge	0.046	0.050	0.054	0.057	0.060	0.062	0.067	0.070	—
Positive moment at mid-span	0.034	0.038	0.040	0.043	0.045	0.047	0.050	0.053	0.034
Two long edges discontinuous									
Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.045
Positive moment at mid-span	0.034	0.046	0.056	0.065	0.072	0.078	0.091	0.100	0.034
Three edges discontinuous (one long edge continuous)									
Negative moment at continuous edge	0.057	0.065	0.071	0.076	0.081	0.084	0.092	0.098	—
Positive moment at mid-span	0.043	0.048	0.053	0.057	0.060	0.063	0.069	0.074	0.044
Three edges discontinuous (one short edge continuous)									
Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.058
Positive moment at mid-span	0.042	0.054	0.063	0.071	0.078	0.084	0.096	0.105	0.044
Four edges discontinuous									
Positive moment at mid-span	0.055	0.065	0.074	0.081	0.087	0.092	0.103	0.111	0.056

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Appendix 2) Shear force coefficient for uniformly loaded rectangular panels supported on four sides with provision for torsion at corners

Table 3.15 — Shear force coefficient for uniformly loaded rectangular panels supported on four sides with provision for torsion at corners

Type of panel and location	β_{vx} for values of l_y/l_x								β_{vy}
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
Four edges continuous									
Continuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33
One short edge discontinuous									
Continuous edge	0.36	0.39	0.42	0.44	0.45	0.47	0.50	0.52	0.36
Discontinuous edge	—	—	—	—	—	—	—	—	0.24
One long edge discontinuous									
Continuous edge	0.36	0.40	0.44	0.47	0.49	0.51	0.55	0.59	0.36
Discontinuous edge	0.24	0.27	0.29	0.31	0.32	0.34	0.36	0.38	—
Two adjacent edges discontinuous									
Continuous edge	0.40	0.44	0.47	0.50	0.52	0.54	0.57	0.60	0.40
Discontinuous edge	0.26	0.29	0.31	0.33	0.34	0.35	0.38	0.40	0.26
Two short edges discontinuous									
Continuous edge	0.40	0.43	0.45	0.47	0.48	0.49	0.52	0.54	—
Discontinuous edge	—	—	—	—	—	—	—	—	0.26
Two long edges discontinuous									
Continuous edge	—	—	—	—	—	—	—	—	0.40
Discontinuous edge	0.26	0.30	0.33	0.36	0.38	0.40	0.44	0.47	—
Three edges discontinuous (one long edge discontinuous)									
Continuous edge	0.45	0.48	0.51	0.53	0.55	0.57	0.60	0.63	—
Discontinuous edge	0.30	0.32	0.34	0.35	0.36	0.37	0.39	0.41	0.29
Three edges discontinuous (one short edge discontinuous)									
Continuous edge	—	—	—	—	—	—	—	—	0.45
Discontinuous edge	0.29	0.33	0.36	0.38	0.40	0.42	0.45	0.48	0.30
Four edges discontinuous									
Discontinuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33

Appendix 3) Areas of groups of bars

Table 4.1 Areas of groups 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 4) Bars spacing data

Table 8.2 Bar spacing data

Diameter (mm)	*Area (mm^2) for spacing mm*												
	s=80	100	120	140	150	160	180	200	220	240	260	280	300
6	350	282	235	201	188	176	157	141	128	117	113	100	94
8	628	502	418	359	335	314	279	251	228	209	201	179	167
10	981	785	654	560	523	490	436	392	356	327	314	280	261
12	1413	1130	942	807	753	706	628	565	514	471	452	403	376
16	2513	2010	1675	1436	1340	1256	1117	1005	913	837	804	718	670

Spacing *s* in millimetres.

Appendix 5) chart of area for stair

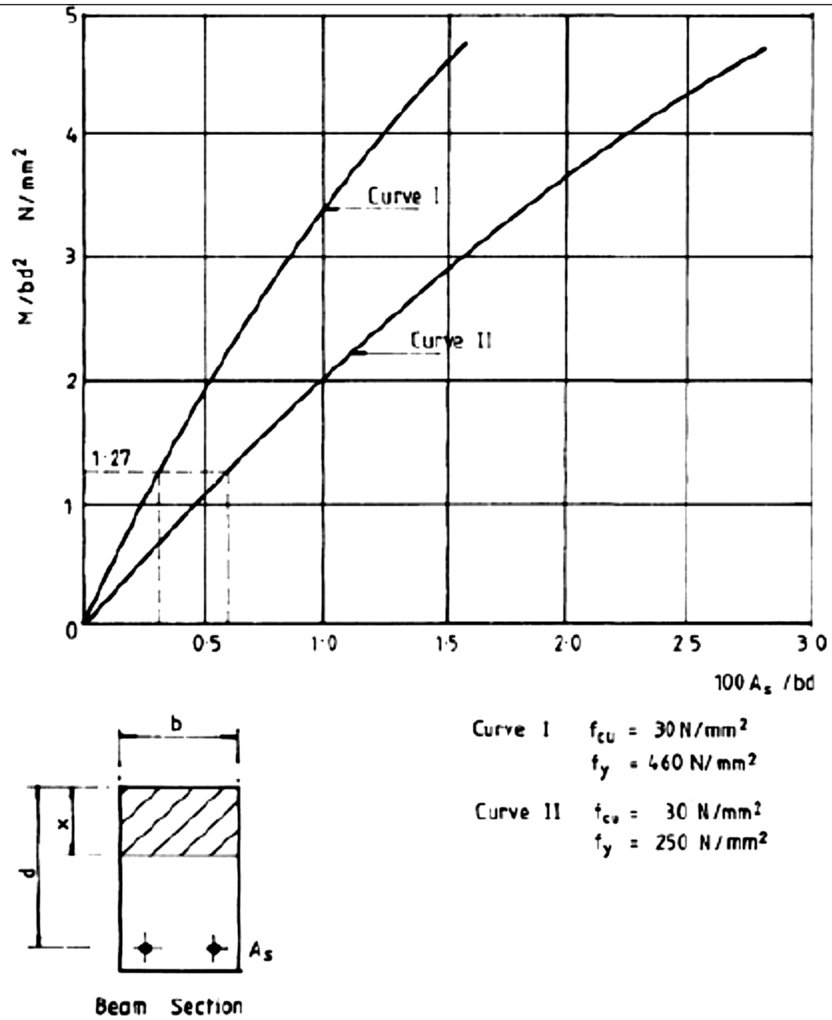
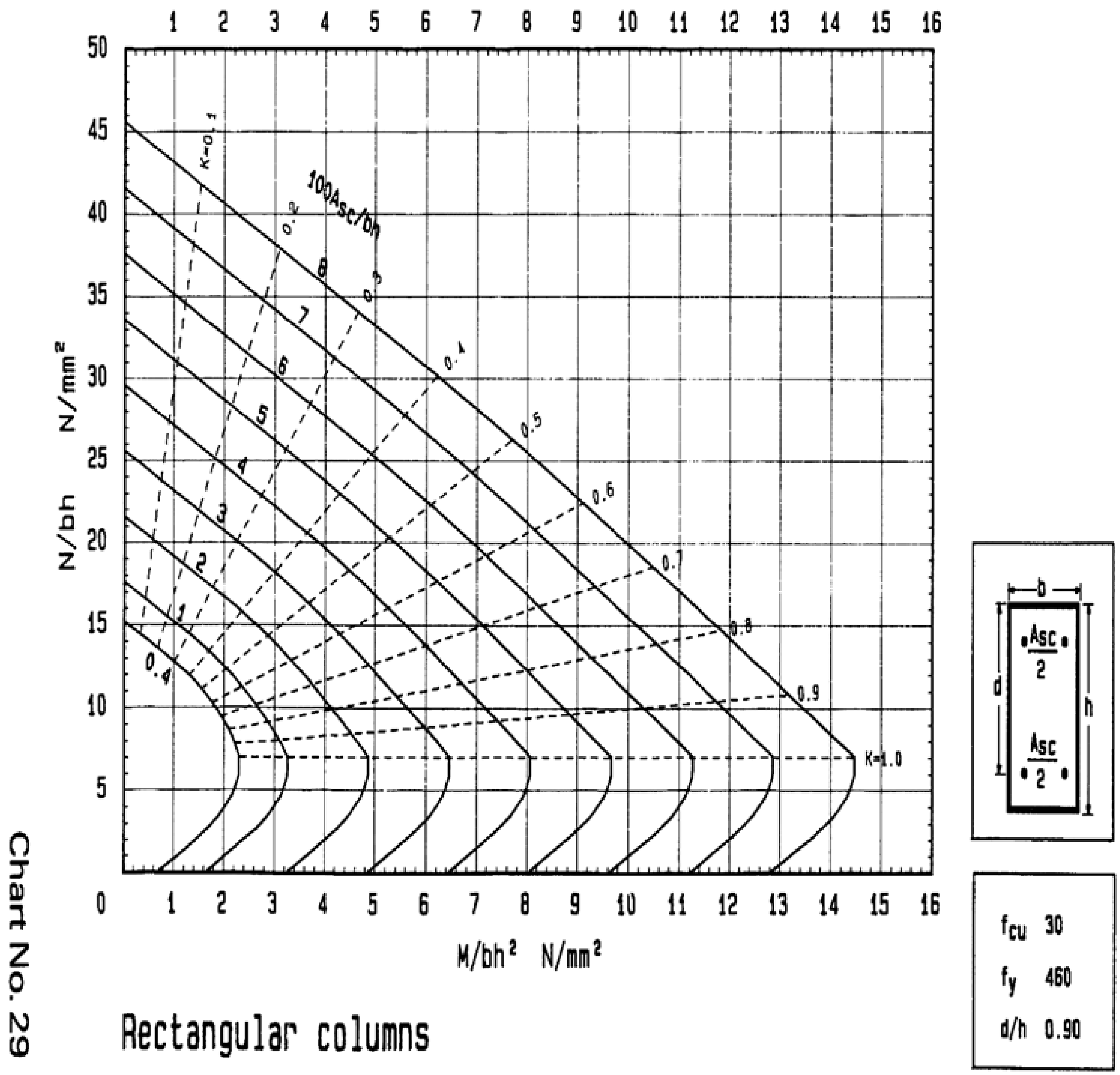
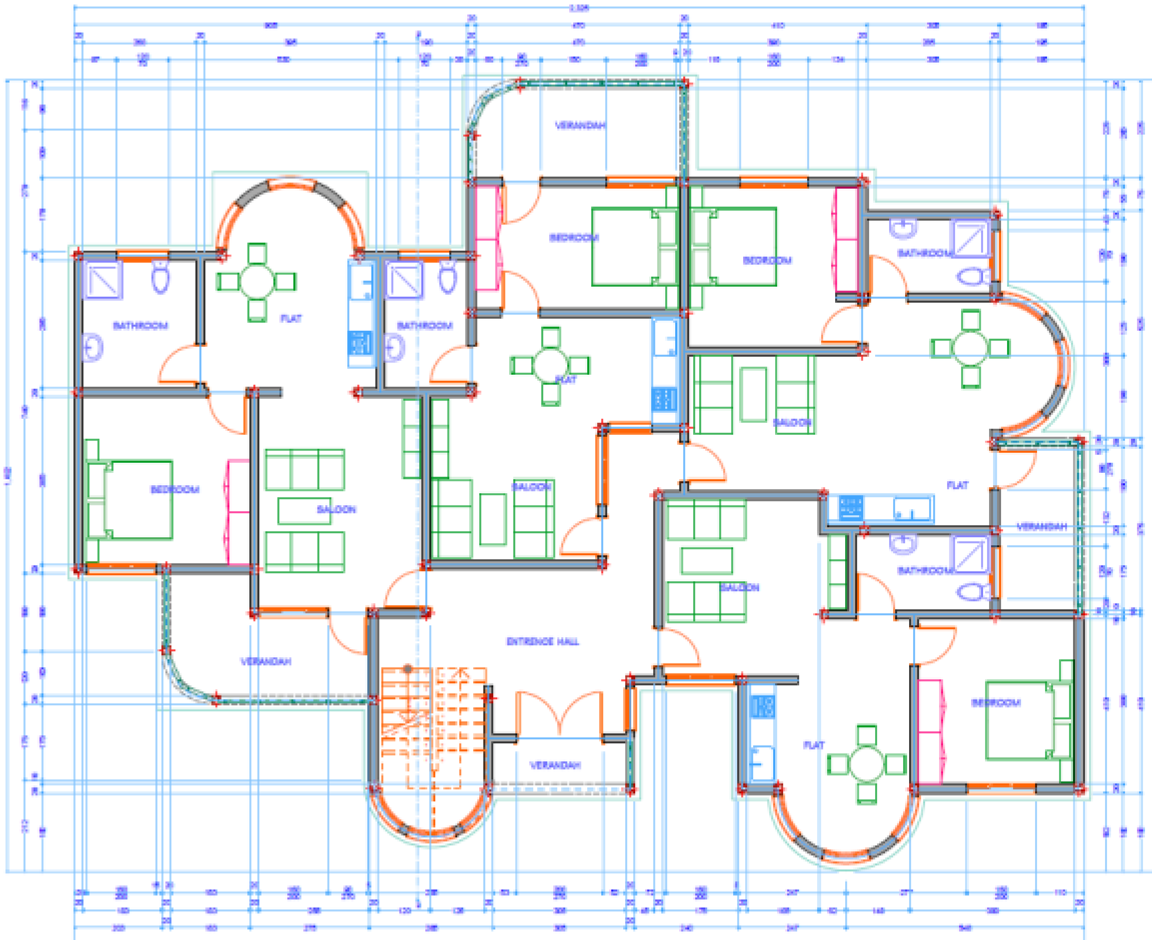


Fig. 4.13

Appendix 6) Chart of area for rectangular column



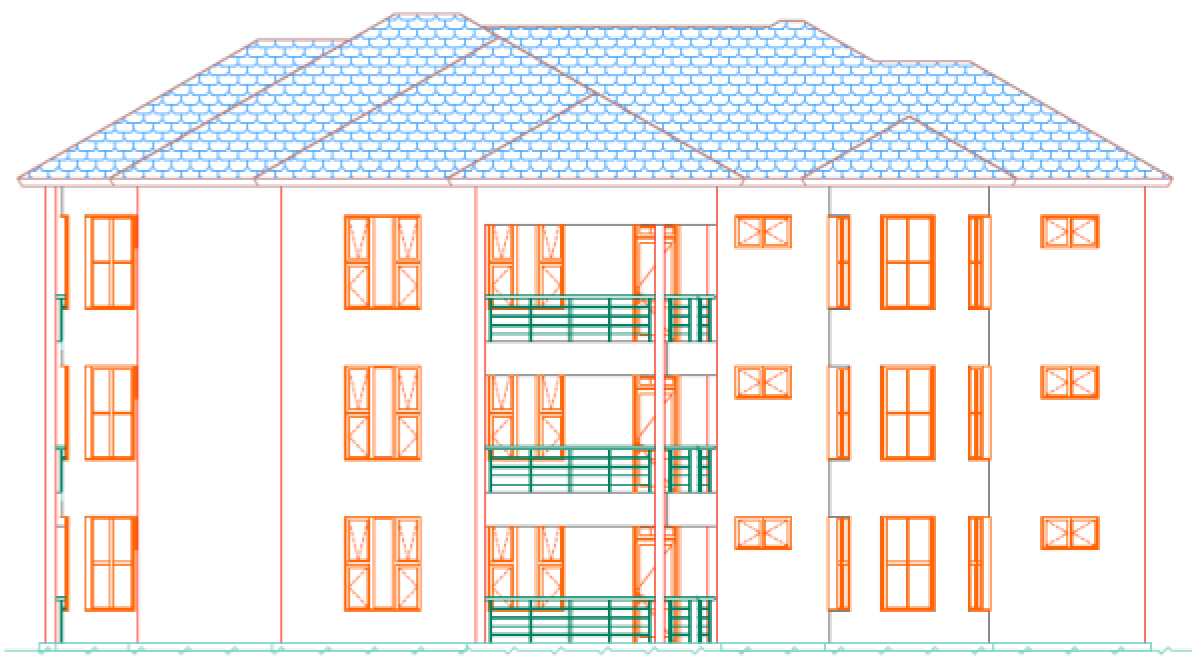
Appendix 7) Floor plans



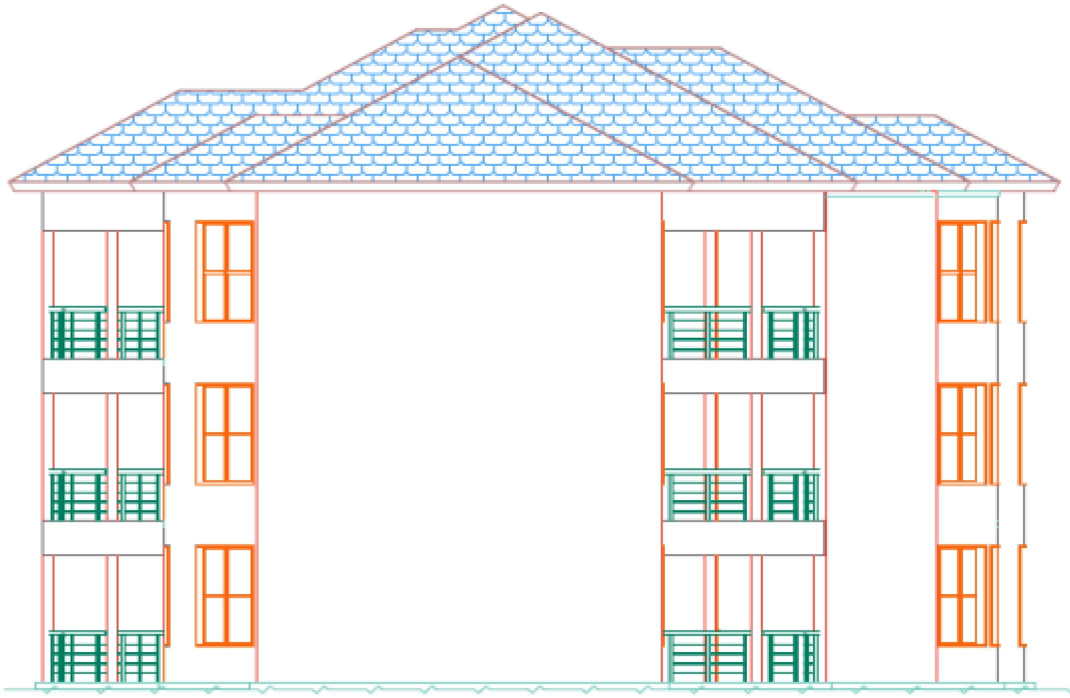
GROUND FLOOR,FIRST FLOOR,SECOND FLOOR

Appendix 8) Front elevation

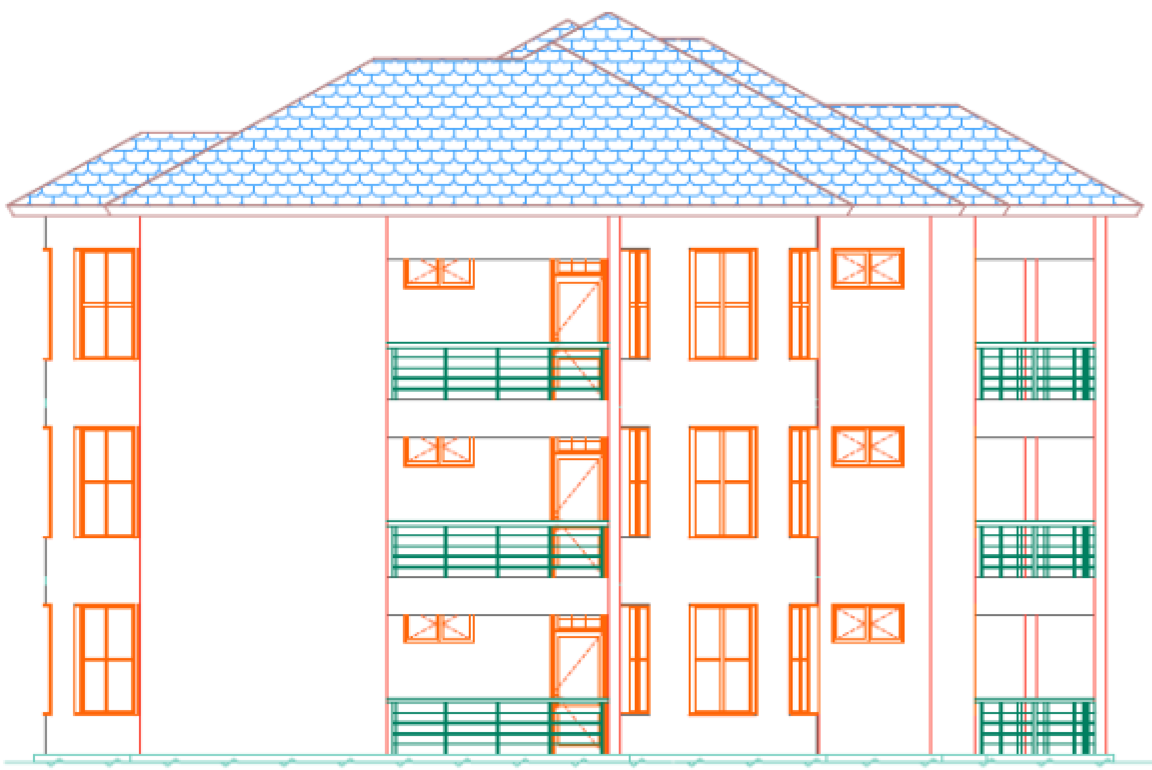
Appendix 9) Back elevation



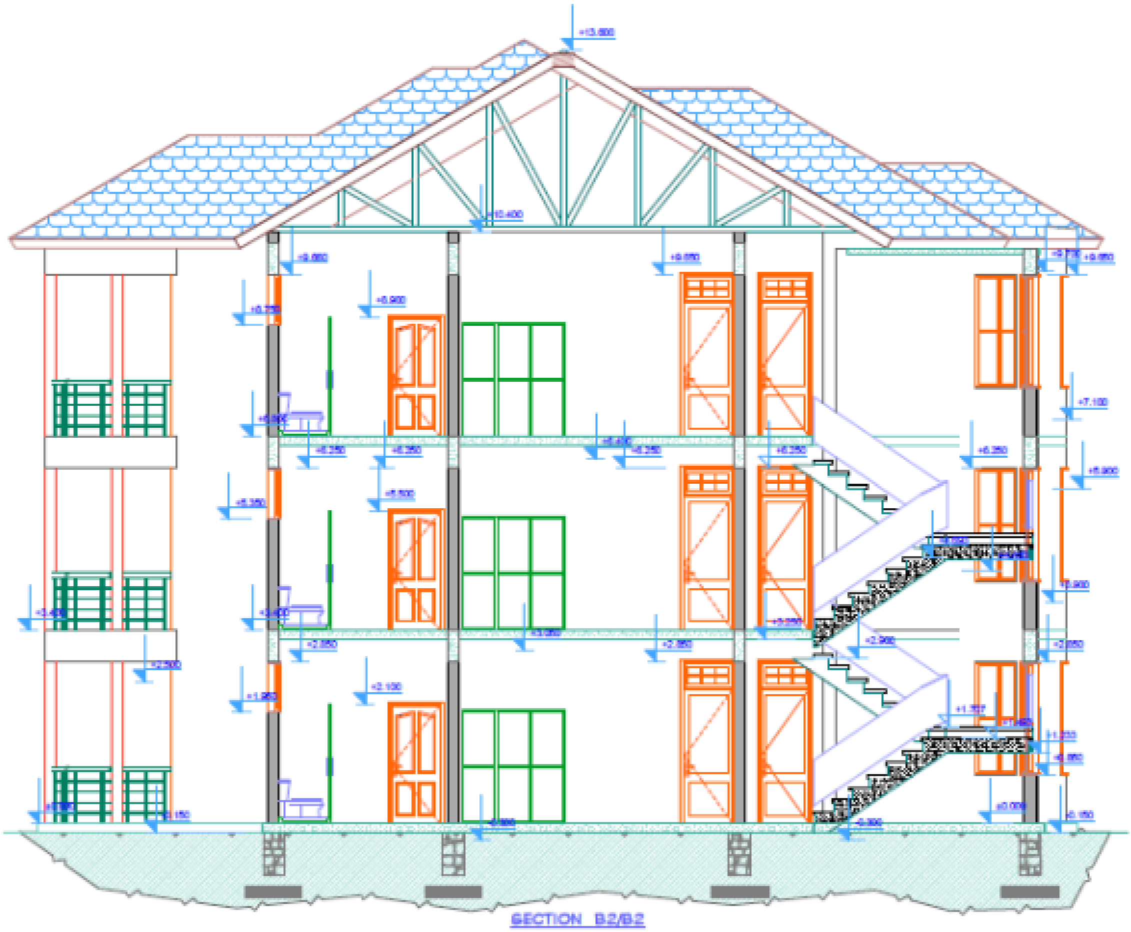
Appendix 10) Right elevation



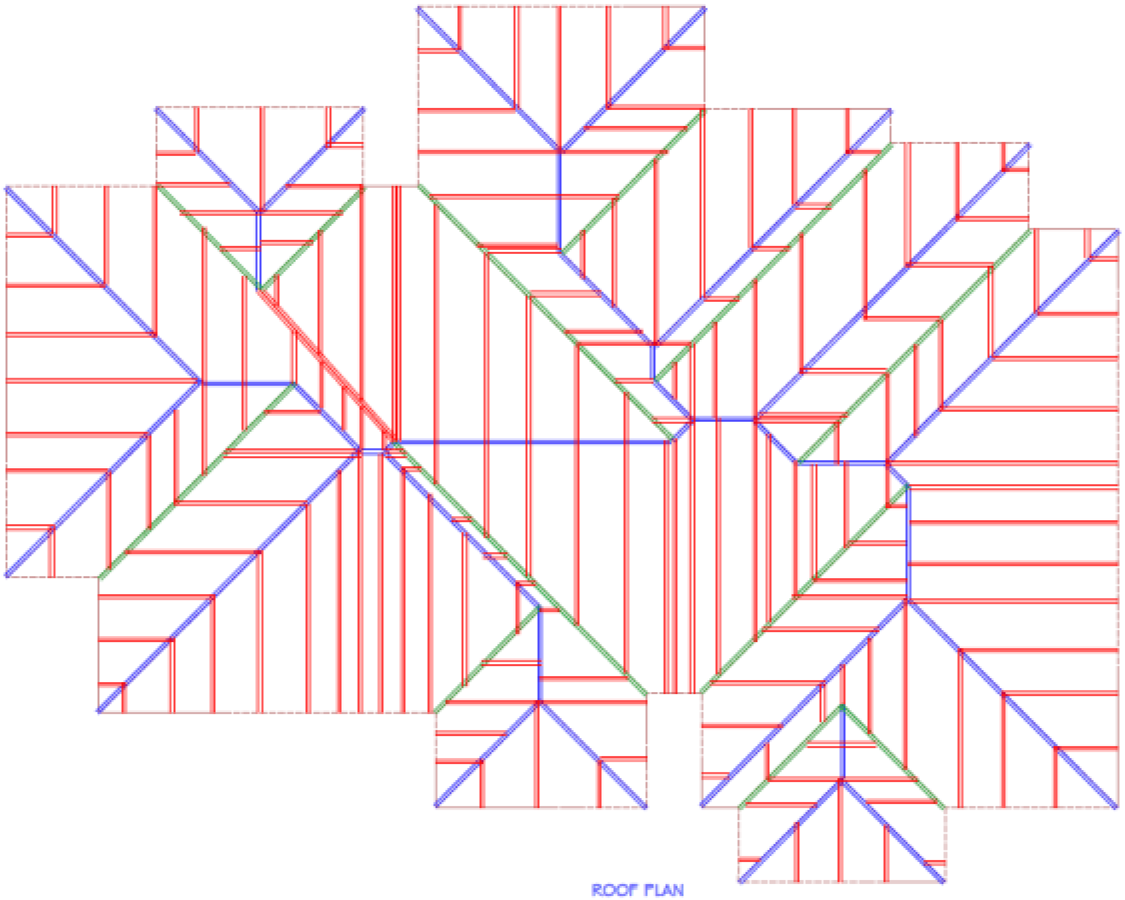
Appendix 11) Left elevation



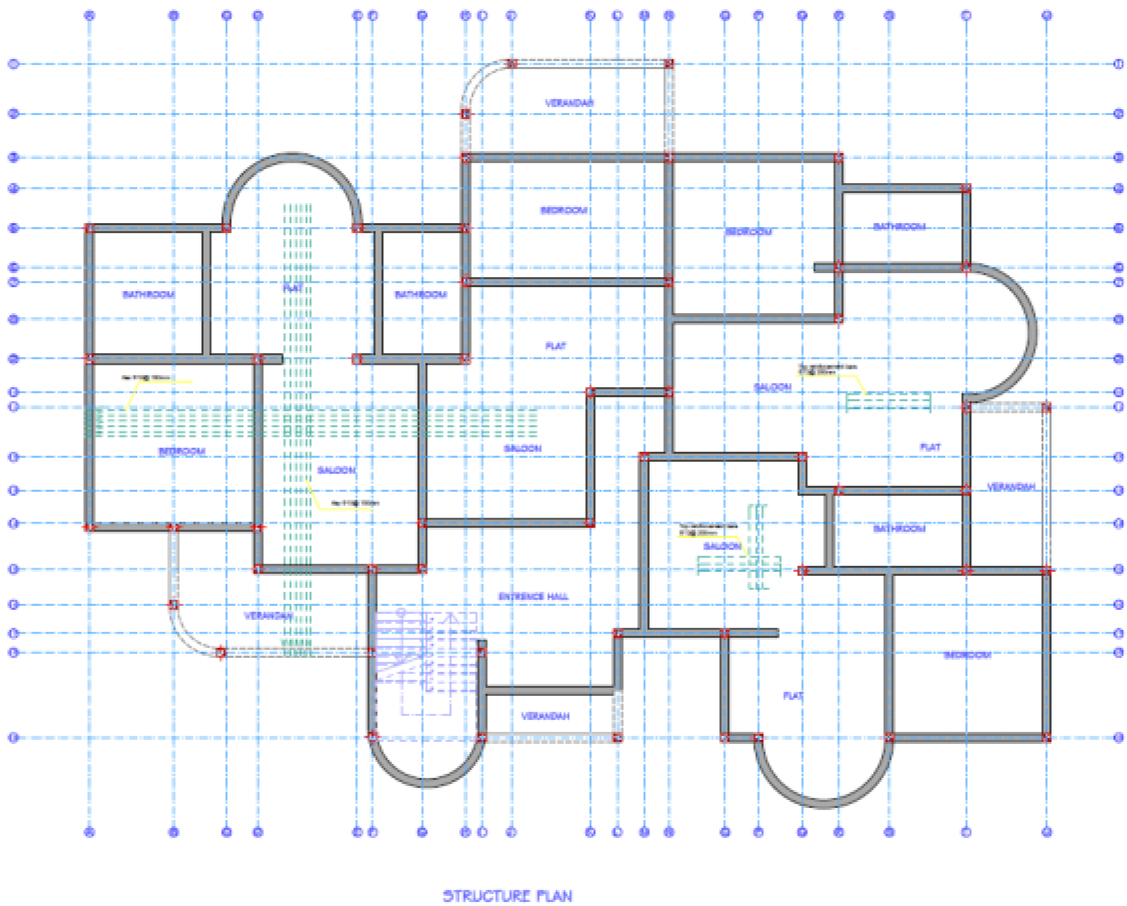
Appendix 12) Building section



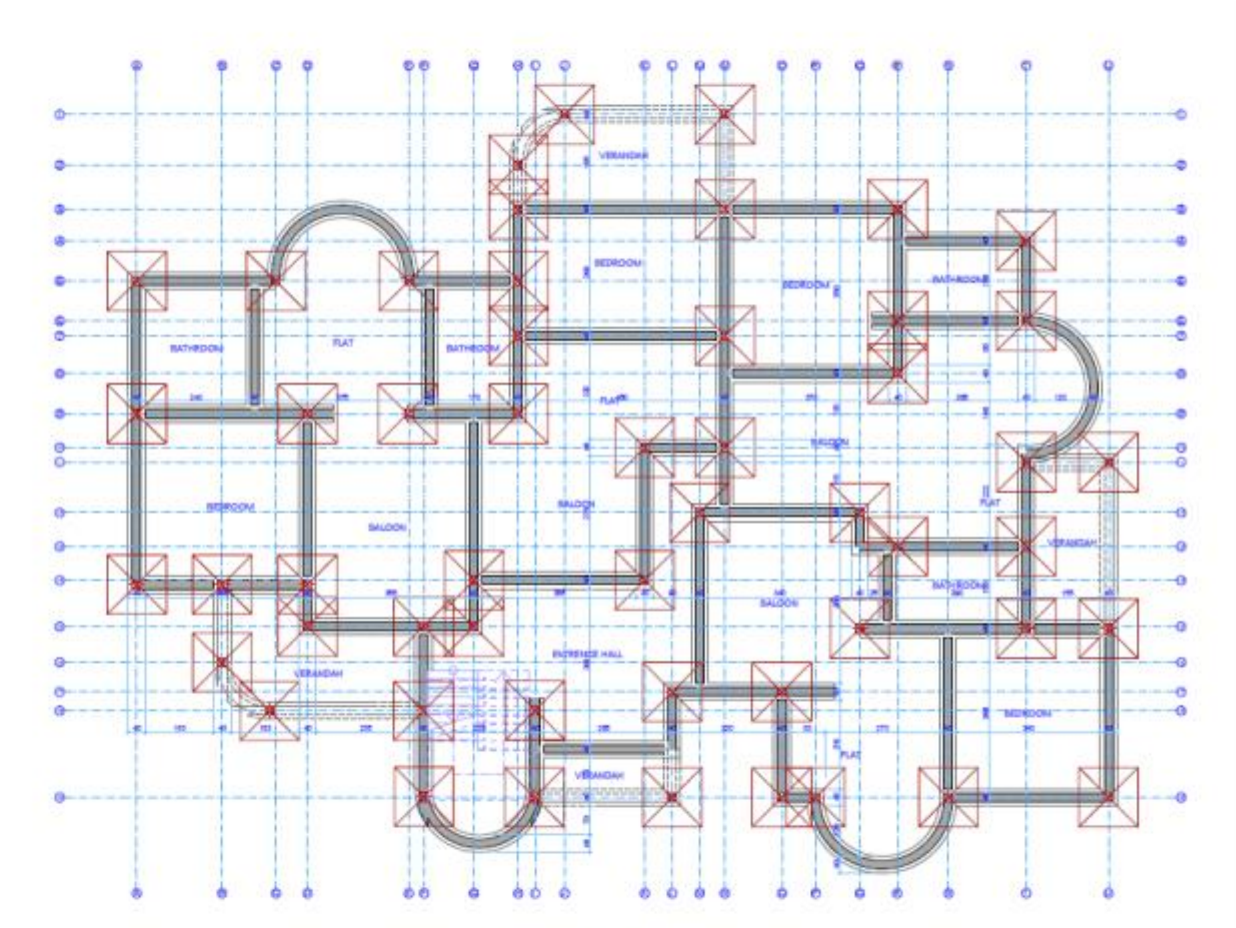
Appendix 13) Roof plan



Appendix 14) Structural plan



Appendix 15) Foundation plan



FONDATION PLAN

Appendix 16) Perspectives