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DEPARTMENT OF CIVIL ENGINEERING

OPTION: CONSTRUCTION TECHNOLOGY

ARCHITECTURAL AND STRUCTURAL DESIGN OF FOUR STORIES BUILDING HOTEL

CASE STUDY: NYAGATARE DISTRICT.

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

Presented by TUMUSIME Emmy

Roll number: 202150550

Under the guidance of Eng. HABIMANA Philibert

Kigali, **September**, 2024

DECLARATION

I TUMUSIME EMMY do hereby declare that the work presented in this dissertation is my own contribution to be the best of our knowledge. The same work has never been submitted to any other University or Institution. I therefore declare that this work is MY own for the partial fulfillment of the award of advanced diploma (A1) in Civil Engineering at ULK POLYTECHNIC INSTUTUTE

TUMUSIME EMMY

Signature …………………………………………

Date of submission: ………………………………

APPROVAL

This is to certify that this dissertation work entitled “structural design of four stories building hotel at nyagatare District case study nyagatare district” is an original study conducted by TUMUSIME Emmy in partial fulfillment of the requirement for the award of advanced diploma in civil engineering department, construction technology option at ULK POLYTECHNIC INSTITUTE during the academic year 2023-2024.

Supervised : Eng. HABIMANA Philbert

Date……………………….

Signature………………………….

DEDICATION

I would dedicate this project to:

The Almighty God

My beloved mother and father

My beloved brothers and sisters

My family and friends

My classmates

ACKNOWLEDGEMENTS

First and foremost, I am humbly thankful my almighty God, the most merciful, for the countless blessings in my whole life, especially in my studies since the beginning up to the completion of this project.

My sincere acknowledgement goes to ULK administration and staff, in particular to the **Eng. HABIMANA Philibert** for his continuous advice, assistance and correction until the end. I am grateful to all staff member of Civil engineering department for his support and useful ideas.

Lastly, I express my gratitude to my family especially parents and brothers, sisters and other people who directly or indirectly contributed to my project and my studies in general to be successful.

ABTRACT

The project entitled "ARCHITECTURAL AND STRUCTURAL DESIGN FOUR STORIES BUILDING HOTEL" was aimed to provide the adequate structural design of the hotel. This should solve the problem of lacking of modern hotel. In order to accomplish this work some methodologies were adopted where, the ARCHICAD software was used to architectural drawing, PROKON and analytical method was used to design Structure elements like slab, beam, column, ground beam, foundation, and stairs.

Cross sections and reinforcements of all structure elements were calculated. Maximum cross section in slab was 3.02 cm2/m with steel reinforcement of 68 /m at the top and bottom, the maximum area of beam was 12.57 cm2 with steel reinforcement of 4Φ20 at the top and bottom was 4Φ14 of steel reinforcement with corresponding area As = 6.16 cm2. The maximum area of ground beam was 6.61 cm2 with the steel reinforcement of 4Φ14 at the top and 6.61 cm2 with steel reinforcement of 4Φ14 at the bottom. Maximum area on ground floor part of column was 39.27 cm2 with steel reinforcement of 418, on first floor part of column was 30.41 cm2with steel reinforcement of 412, on second floor part of column was 25.13cm2 with steel reinforcement of 412, on third floor part of column was 20.36 cm2 with steel reinforcement of 412, on fourth floor part of column was 16.08 cm2 with steel reinforcement 612, for stairs the maximum area was As =10.18cm2/m with steel reinforcement .

LIST OF SYMBOLS AND ABREVEATIONS

A: cross section area

Ac: total cross-section area of concrete section

As: area of tensile steel

As‘‘: area of compressive reinforcement

ASV: area of steel in links

B: width of foundation

B: width of reinforced concrete section

Bf: width of flange in a beam

BW: width of web in a beam

C: cover

D: effective depth of tensile reinforcement

D: depth of foundation

E: young’s modulus

Fcu: characteristic yield strength of concrete

Fv: shear force

Fs: estimated design service stress in the reinforcement

Fsv: characteristic yield strength of the links

FY: characteristic yield strength of steel

G: going

H: overall depth of a concrete section

Hf: thickness of flange in a T-beam

L: span length

Lx: short-span length

Ly: long-span length

Rb: Design concrete compressive strength

Rs: Design steel tensile strength

M: maximum moment that the reinforced concrete element will resist

Mc: Moment capacity

N: ultimate axial load on column

Pa: allowable bearing pressure

.t: thickness

V: shear force

N: number of blow

Φ: Diameter of steel

RDF: Depth correction factor

SA: Permissible stress

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CHAPTER ONE: GENERAL INTRODUCTION

1.1. Introduction

1.1.1 Background of the study

Hospitality industry has strongly sustained rise of over the past fifty years is one of the most remarkable phenomena of our time over the world. Activities continue to grow steadily, in spite of some various factors such as hotel and sustainable development, which obviously affect the industry. With the substantial growth in the Hospitality industry, this sector has become one of the world biggest industries. It's also the largest and fastest growing and dynamic economic sector ((J. M Hamilton & Richard S.J. Tol)

The Hospitality industry employs more people than the automobile, electronics, steel and textile industry combined. This sector currently supported more than 21.5 million jobs, in year 2021, it's projected to be the largest industry in the world with an estimation of 10.5% employees in World and more than 112 million people internationally ((Daya)

Rwandan government has identified hospitality industry as one of priority sectors in achieving vision 2020 and contributor to the eradication of poverty in the country.

The worldwide consensus that employment generated by hospitality industry can be substantial in many national economies, contributing to their economic growth and providing income to people. Sustainable Development reported as development that meets the needs of the present with-out compromising the ability of future generations to meet their own needs.so Rwanda of a thousand hills also contributes to hospitality industry especially in eastern province nyagatare district due to its natural and attractive features.

1.2 Problem Statement

Rwanda is developing country with about 90% of population engaged in agriculture with limited participation in market economy (30 to 50% of rural population on a given year may not produce a marketable surplus, it is the most densely populated country in Africa, landlocked with few natural resources and minimal industry and its depends heavily on its natural resources; land, forests, water and wildlife ((MINECOFIN, (2008.)

Like other developing countries, Rwanda need to achieve sustainable development whereby the government of Rwanda is undertaking various policies and measures for sustainable development

The hospitality industries contribute to a balanced and healthy economy by generating hotel-related jobs, revenues, and taxes while protecting and enhancing the destinations social-economic, cultural, historical, natural and built resources for the enjoyment and well-being of both residents and visitors.

Number of tourists coming in Rwanda increase day to day especially in **NYAGATARE** district due to its natural and attractive features, and because of many attractive things whereby those tourists need hotels for accommodation. The peculiarity of Rwanda in terms of shortage of land cannot overlooked, hence multi-storey building needed for sustainable hotel, but more clarification is needed to know what will extent by doing design multi-storey building for sustainable hotel, so it is worth to do study whose title is Structural design of four stories building for sustainable hotel.

1.3 Objectives of study

1.3.1 Main objective

The main objective of this study is a structural design of four stories building hotel located at nyagatare district

1.3.2 Specific objectives

- The specific objectives of this study are the following:
- To make a structural design of the hotel
- To make a bill of quantity of different item of work
- To increase knowledge and skills in my carrier
- To give references to young brothers who will study construction technology

1.4. Significance of the study

This study is made with interests such as personal interest, academic interest, and social interest.

1.4.1. Personnel benefits

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

This study work is primarily designed to contribute to the role of architectural and structural design of multi-storey hotel for sustainable hotel in Rwanda, especially in nyagatare sector; as such we are interested in studying the role of multi-storey building hotel in land use management in Rwanda.

1.4.2. Academic Interest.

This project will be in the library of the institution and it will help students in civil engineering, this study also helps the students because the academic Law recommends that each student must do a study work in order to achieve the end of studies

1.4.3. Social Interest

This project helps the Planners or Government what they do for achieving a sustainable development in using multi-story building for sustainable hotel and it helps to the readers of this dissertation to know the impact of multi-story building for in promotion of sustainable hotel and land use management in Rwanda.

1.4.4 Scientific Interest

Scientific issue, this project helps the other student for this field for doing the other study to the same field. This project also helps the students because the academic Law recommends that each student must do a study work in order to achieve the end of diploma

1.5. Scope of the study

This project focuses on the following:

- Architectural design
- Engineering design
- Structural design

1.6. Organization of the study

This project study is divided into five chapters.

The chapter one deals with the general introduction which presents the background to the study, the problem statement, the objectives, the study questions, significance and scope of the study, while the second chapter deals with the literature review, which highlights the theoretical framework related to Architectural and Structural Design of Four multi-storey building for sustainable hotel

The third chapter concerns in much more the methodological details, while the forth chapter deals with Architectural and Structural element design overview, data presentation, their analysis and interpretation of findings. Finally, the fifth chapter is about, conclusions and recommendations or suggestions.

CHAPTER TWO: LITERATURE REVIEW

2.1. Architecture

Concerned with the selection of architectural elements, their interaction, and the constraints on those elements and their interactions. Design are concerned with the modularization and detailed interfaces of the design elements, their algorithms and procedures, and the data types needed to support the architecture and to satisfy the requirements." Software architecture is "concerned with issues beyond the algorithms and data structures of the computation (" (Eden, 2003.)

2.2. STRUCTURE

The assemblage of two or more basic structural components connected together in such a way that they serve the user functionally and carry the load arising out of the self and superimposed loads safely without causing any problem of serviceability. Basic structural components in a building are the beams, the columns, the slabs and the footings. These components when connected in a proper way form a building ((B.D.NAUTIYAL,, 2001.)

A structure can be defined as a body which can resist the applied loads without appreciable deformations. Civil engineering structures are created to serve some specific functions like human habitation, transportation, bridges, storage etc., in a safe and economical way.

A structure is an assemblage of individual elements like pinned elements (truss elements), beam element, column, shear wall slab cable or arch. Structural engineering is concerned with the planning, designing and the construction of structures. Structure analysis involves the determination of the forces and displacements of the structures or components of a structure ((K.Hari, 2011)

2.3. DESIGN

The design is made using software on structural analysis design (stead-pro). The building subjected to both the vertical loads as well as horizontal loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc., and live loads. The horizontal load consists of the wind forces thus building is designed for dead load, live load and wind load as per IS 875.

The building is designed as two dimensional vertical frame and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per IS 456-2000. The help is taken by software available in institute and the computations of loads, moments and shear forces and obtained from this software (Kumar, 2011)

2.4. Multi-story building

A multi-story building is a building that supports two or more floors above ground. There is no formal restriction on the height of such a building or the number of floors a multistory building may contain; though taller buildings do face more practical difficulties.

A multi-story building may be designed as a place of business, such as a hospital, a law firm, a casino, a mall or a government building. Other types of multi-story buildings include apartment compounds and local museums. Some communities include many multi-story apartment buildings to provide adequate housing within the local area, or to meet the housing needs of a growing community (K.Hari, 2011)

2.5. Building

Building construction is the engineering deals with the construction of building such as residential houses. In a simple building can be define as an enclose space by walls with roof, food, cloth and the basic needs of human beings. In the early ancient times humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Rich people live in sophisticated condition houses.

Buildings are the important indicator of social progress of the county. Every human has desire to own comfortable homes on an average generally one spends his two-third life times in the houses.

The security civic sense of the responsibility. These are the few reasons which are responsible that the person do utmost effort and spend hard earned saving in owning houses (K.Hari, 2011)

2.6. Analysis of the Hotel Concept

Nowadays, traveling is becoming more and more common activity. The growth of economy in some countries gives the opportunity to not only travel more, but also use the early retirement opportunities, and thus become consumers of tourism products. The growth of the youth market has also played a significant role for increase of traveling.

Young people today have become experienced consumers of hotels, air planes and frequent travelers to various tourist destinations. Technological change is a very important factor for growing tourism, as development of transportation means (cars, trains, and air jets), telecommunication systems and others gave an opportunity to people to communicate and travel easily and get all the necessary information quicker. The social change influenced the increase of consumption in all aspects. The growing influence of mass media and expanding the facilitating means (credit cards, store cards, mail order, and television shopping channels) made products and services more available. (Williams, 2002.)

the increased globalization made the influence of multinational companies more significant and made traveling a necessary prerequisite of developing and expanding business. These factors insured the expanding of tourism; actually the increasing number of people can afford traveling.

(Jones et al.,, 2006 .) claim that every day 300 million people sleep away from home. Today the motivations that make people stay away from home can be different: business, meetings, leisure, culture, religion, education and health, visiting friends or relatives. And when people visit some place

2.7. Structure elements analysis

2.7.1. Slab

The slab provides a horizontal surface and is usually supported by columns, beams or walls.
Slabs can be categorized into two main types: one-way slabs and two-way slabs. One-way slab is the most basic and common type of slab. One-way slabs are supported by two opposite sides and bending occurs in one direction only. Two-way slabs are supported on four sides and bending occurs in two directions.

2.7.2. Beam

Can be described as members that are mainly subjected to flexure and it is essential to focus on the analysis of bending moment, shear, and deflection. When the bending moment acts on the beam, bending strain is produced. The resisting moment is developed by internal stresses. Under positive moment, Compressive strains are produced in the top of beam and tensile strains in the bottom.
The T-shape and L-shape beams are typical types of beam because the beams are built monolithically with the slab. When slab and beams are poured together, the slab on the beam serves as the flange of a T-beam and the supporting beam below slab is the stem or web. For positive applied bending moment, the bottom of section produces the tension and the slab acts as compression flange. But negative bending on a rectangular beam puts the stem in compression and the flange is ineffective in tension. Joists consist of spaced ribs and a top flange ((Choi, 2002.)

2.7.3. Column

A column is vertical structural element that transmits, through compression, the weight of the structure above to the foundation. For the purpose of wind or earthquake, column may be designed to resist lateral forces (Schwartz, 1993)

Although the column is essentially a compression member, the manner in which it tends to fail and the amount of load that causes failure depend on:

The first point is obvious: a steel column can carry a greater load than a timber column of similar size. Columns with a large cross-section area compared with the height are likely to fail by crushing. These „short columns" have been discussed earlier (F. & Morgan, , 2010)

Reinforced concrete columns are categorized into five main types; rectangular tied column, rectangular spiral column, round tied column, round spiral column, and columns of other geometry (Hexagonal, L-shaped, T-Shaped, etc.).

Tied columns have horizontal ties to enclose and hold in place longitudinal bars. Ties are commonly No. 3 or No.4 steel bars. Tie spacing should be calculated with ACI (American Concrete Institute) Code. Spiral columns have reinforced longitudinal bars that are enclosed by continuous steel spiral. The spiral is made up of either large diameter steel wire or steel rod and formed in the shape of helix. The spiral columns are slightly stronger than tied columns.

The columns are also categorized into three types by the applied load types; the column with small eccentricity, the column with large eccentricity (also called eccentric column) and biaxial bending column. (Choi, , 2002)

Eccentricity is usually defined by location: Interior columns usually have Exterior columns usually have large eccentricity Corner column usually has biaxial eccentricity. But eccentricity is not always decided by location of columns (Choi, , 2002)

2.7.4. Footing

The foundation of a building is the part of a structure that transmits the load to ground to support the superstructure and it is usually the last element of a building to pass the load into soil, rock or piles.

The primary purpose of the footing is to spread the loads into supporting materials so the footing has to be designed not to be exceeded the load capacity of the soil or foundation bed.

The footing compresses the soil and causes settlement. The amount of settlement depends on many factors. Excessive and differential settlement can damage structural and nonstructural elements. Therefore, it is important to avoid or reduce differential settlement (Schierle G., 2002)

2.7.5. Stairs

Stairs are designed as reinforced concrete slabs whose depths are equal to the waist thickness of the stair, and which are normally an integral part of the structure.

The requirements in respect of the ratio of span to depth which is specified are the same as for one-way-spanning slabs (Macdonald, , 1994)

A Stair is a system of steps by which people and objects may pass from one level of a building to another.

A stair is to be designed to span a large vertical distance by dividing it into smaller vertical distances, called steps (Ascroft, 1992)

2.8. Structure composite materials

2.8.1. Concrete

Concrete is a poor material for tensile strength and it is not suitable for flexure member by itself. Otherwise Concrete is one of the most popular materials for buildings because it has high compressive strength, flexibility in its form and it is widely available. Despite the high compressive strength, concrete has limited tensile strength, only about ten percent of its compressive strength and zero strength after cracks develop. Also it is essential that concrete and steel deform together and deformed reinforcing bars are being used to increase the capacity to resist bond stresses (Schierle,, 2002)

2.8.2. Cement

Cement is made from limestone, which is mainly calcium carbonate. Limestone is mined and processed by crushing and roasting, or calcining, it with clay in rotating kilns. This leaves a dehydrated porous material called clinkers. The clinkers are ground into a fined powder called cement, which is used to make concrete. The most used cement is Portland cement (Schwartz, , 1993)

All of the cements which are used for structural concrete are dependent on water for the development of strength; when water is added to dry cement a fairly complex series of chemical reactions takes place in a process which is called hydration and which causes the resulting paste to stiffen (J.Macdonald, , 1997)

2.8.3. Aggregates

Aggregate, being cheaper than cement, is used as a bulking agent in concrete and, typically, will account for 75% to 80% of its volume. It also serves to control shrinkage and to improve dimensional stability. It normally consists of small pieces of stone, of various sizes in the form of either naturally occurring sand or gravel, or crushed rock fragments; other materials, such as crushed brick, blast furnace slag or recycled building materials, are sometimes used. Aggregate must be durable, of reasonable strength, chemically and physically stable, and free of constituents which react unfavorably with cement (J.Macdonald,, 1997)

2.8.4. Water

Water has a key role in the production of concrete, it is an important ingredient. It changes the loose mixture into a rock-like solid material. When you mix water with cement, it makes a paste. The paste goes around the particles and fills in the empty spaces. Typically, 150 to 200 kg/m3 of water are used. The old rule of thumb for water quality is “If you can drink it, you can use it in concrete (Schwartz, 1993)

2.8.5. Reinforcement

The reinforcement which is used in concrete is normally in the form of steel bars, either of plain circular cross-section or with various surface treatments which increase the bond with the concrete. The preferred diameters are 6, 8, 10, 12, 16, 20, 25, 32 and 40 mm, and the normal maximum length is 12 m. The steel reinforcement resists all tensile bending stress because tensile strength of concrete is zero when cracks develop. Reinforcement is produced in both mild steel and high-yield steel (J.Macdonald,, 1997)

2.9. Load on structures

The principal forms of loading to which buildings are subjected are gravitational loads, wind pressure loads and inertial loads caused by seismic activity. Gravitational loads, which are caused by the weight of the building itself and of its contents, act vertically downwards; wind and seismic loads have significant horizontal components but can also act vertically.

To perform satisfactorily a structure must be capable of achieving a stable state of static equilibrium in response to all of these loads to load from any direction, in other words.

Dead loads: Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. Dead load is the total load of all of the components of the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc.

For most reinforced concrete a typical value for the self-weight is 24KN cubic meter. But a higher density should be taken heavily reinforced or dense concretes. In the case of building, the weights any partitions should be calculated from architect's drawings. A minimum partition imposed loading of 1.0KN per square meter is usually specified, but this is only adequate for light weight partitions.

Live (imposed loads): Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. The uniform and concentrated live loads should not be applied simultaneously n a structural evaluation. Concentrated loads should be applied to a small area or surface consistent with the application and should be located or directed to give the maximum load effect possible in endues conditions.

Wind loads: this load depends on the location and building size. (Codes of practice give guidance on how to compute the wind load)

The pressure exerted by the wind is related to the square of its velocity. Due to the roughness of the earth's surface, the wind velocity at any particular instants of an average velocity plus superimposed turbulence, referred to as gusts. As a result, a structure subjected to wind loads assumes an average deflected position due to the average velocity pressure and vibrates from this position in response to the gust pressure.

Snow Loads: snow accumulation on roofs is influenced by climatic factors, roof geometry, and the exposure of the roof to the wind. Unbalanced snow loads due to drifting or sliding of snow or uneven removal of snow by workers very common. Large accumulations of snow often will occur adjacent to parapets or other points where roof heights change

Construction Loads: during the construction of concrete building, the weight of the fresh concrete is supported by formwork, which frequently rests on floors lower down in the structure. In addition, construction materials are often piled on floors or roofs during construction. ACI Code Section 6.2.2.2 states the following No construction loads exceeding the combination of superimposed dead load plus specified live load shall be supported on any unshared portion of the structure under construction, unless analysis indicates adequate strength to support such additional loads (W.H.Mosley, , 1976)

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This chapter describes the study area and the methods with tools used to fulfill the objectives of this study, the methodology used to collect data from the field, which means the way followed in order to obtain the required information, the materials, and equipment. It describes the process by which the study was carried out and analysis data what was done. It includes various collaboration techniques.

In Methodology include method and tools used in this study that help to get how the report did. In this project report, there is the show the multi-storey hotel at nyagatare sector sector; this building will increase the tourism; the sustainability economic and an adequate with achievement of that structural design, there is the use of software such as: Archcad used for drawing and Prokon, which used for calculating the reinforced concrete design within diagrams.

3.1 Case study description

Hotel construction is especially reinforced concrete structure. The project site is a rectangular shape includes four stories, first storey composed by employee's services, second storey composed by officers (leaders) rooms with services for clients such as: restaurant, bar. Wherever all rest storeys (level) are contain lodges whole structure is in reinforced concrete.

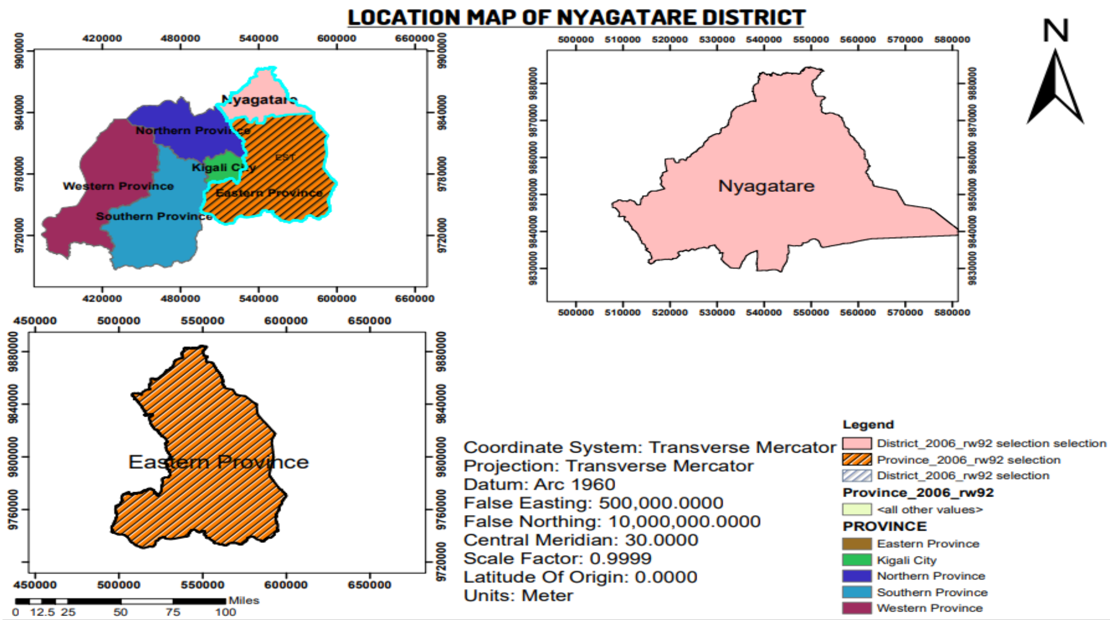


Figure3. 1. Study area map of nyagatare district

3.2. Observation

Is a crucial method in the study methodology of your project. It involves collecting data and insights through direct interaction with the site and surroundings of the proposed hotel in the Nyagatare sector. By physically visiting the location, the student gathers firsthand information on several key aspects:

Site Conditions Observing the topography, existing structures, and environmental factors that could impact the design and construction of the hotel. This includes the layout of the land, drainage patterns, and any potential obstacles or advantages for construction.

Building Design: Observing existing multi-story buildings, particularly hotels, within the area or similar environments. This helps in understanding architectural trends, structural forms, and sustainable practices that are being implemented locally. Direct observation can reveal practical design solutions and challenges that might not be evident from secondary data.

Sustainability Considerations: Observing the sustainable features in current buildings, such as energy efficiency measures, material usage, and waste management practices. This can provide insight into what works well in the local context and what could be improved upon in the design of the new hotel.

Community Interaction: Engaging with the local community and stakeholders to observe their needs, concerns, and expectations regarding the hotel development. This qualitative data is essential for ensuring that the design is not only structurally sound but also socially responsible and acceptable.

3.3. Office Equipment and Software Used

3.3.1. Software and Their Function

ArchiCAD: ArchiCAD is comprehensive architectural BIM (Building Information Modeling) software that allows for the creation of detailed virtual models of buildings. It enables architects to visualize the entire project in 3D, facilitating better decision-making during the design phase. The software supports various tasks, including drafting, documentation, and collaboration with other professionals. Its ability to manage complex designs makes it ideal for designing multi-storey hotels, as it streamlines the process of creating accurate drawings and models.

Prokon: Promon is specialized software for structural analysis and design, particularly useful in the design of beams, columns, and other structural elements. It offers a range of tools for analyzing different structural scenarios, ensuring that the design meets safety and performance standards. Prokon's customization options allow it to be tailored to specific project needs, making it an essential tool for ensuring that the hotel's structural components are robust and compliant with regulations.

3.3.2. Office Equipment and Their Function

Microsoft Office Excel: Excel is used for creating and managing spreadsheets, which is vital for tasks like calculating the bill of quantities (BOQ) and estimating project costs. It allows for the organization and analysis of data, ensuring that the financial aspects of the project are accurately tracked and managed.

Microsoft Office Word: Word is essential for documenting the study process, writing reports, and preparing the final project documentation. It is used for drafting literature, creating diagrams, and formatting the final report.

Laptop: The laptop is the primary device where all the software tools are installed and used. It serves as the central hub for managing all aspects of the project, from design to documentation. The laptop's processing power and portability make it an indispensable tool for both office and on-site work, allowing the student to work efficiently in different environments.

CHAPTER FOUR: STRUCTURAL ELEMENTS DESIGN

4.0 INTRODUCTION

This chapter deals with interpretation according to the findings in the design of the structure. The main consideration in this design is to ensure against the failure of superstructure and to check if it has the ability to carry the anticipated loading with an adequate margin of safety, so that it does not deform excessively within service.

This CHAPTER will also focus on the core objectives and considerations in the structural design of a building, emphasizing the importance of ensuring the safety, stability, and serviceability of the structure. Here's a deeper explanation of the key points:

4.1. Interpretation of Findings

Meaning: This refers to the process of analyzing and understanding the results obtained from the design calculations, simulations, and any other assessments conducted during the structural design process.

Importance: Interpretation is crucial because it allows the engineer to assess whether the design meets the necessary criteria for safety and functionality. It involves evaluating the design against codes, standards, and performance expectations.

2. Ensuring Against Failure of the Superstructure

- **Superstructure:** The superstructure refers to the portion of the building above the ground level, including floors, columns, beams, walls, and the roof.
- **Failure Prevention:** Ensuring against failure means designing the superstructure in such a way that it remains intact and functional under all expected conditions, including the weight of the building materials, occupants, furniture, and any external forces like wind or seismic activity.
- **Safety Considerations:** The design must account for worst-case scenarios to prevent collapse or structural failure, which could lead to loss of life and property damage.

3. Ability to Carry Anticipated Loading

- **Anticipated Loading:** This includes all the forces and loads that the structure is expected to support throughout its life. These can be:
  - **Dead Loads:** Permanent static forces from the building's weight (e.g., walls, floors).
  - **Live Loads:** Temporary or dynamic forces (e.g., people, furniture, movable objects).
  - **Environmental Loads:** Forces from environmental factors (e.g., wind, earthquake, snow).

- **Load-Bearing Capacity:** The structure must be designed to bear these loads without compromising safety or functionality. This requires careful calculation and consideration of material strengths, load distribution, and structural integrity.

4. Adequate Margin of Safety

- **Margin of Safety:** This refers to the factor of safety built into the design, which ensures that the structure can withstand loads greater than those it was designed for. It accounts for uncertainties in material properties, construction quality, and unexpected loads.
- **Design Codes and Standards:** Structural design codes often specify minimum safety factors to ensure that even if there are unexpected loads or material weaknesses, the structure will not fail.

5. Preventing Excessive Deformation

- **Deformation:** This refers to the bending, twisting, or other forms of displacement that can occur in a structure under load.
- **Serviceability:** The structure must remain functional and comfortable to use. Excessive deformation can lead to cracking, misalignment, or even failure of non-structural components like windows and doors.
- **Acceptable Limits:** The design must ensure that any deformations are within acceptable limits so that the building remains safe and usable throughout its life.

6. Service Life

- **Service Life Considerations:** The structure must be designed to perform effectively for the duration of its intended life span, resisting wear and tear, and environmental conditions without significant degradation.

4.2 Slab design

Design information and calculation

- ❖ Design codes: BS8110,6399
- ❖ For a slab design, the consideration is taken according to the large panel. Slab is the same at all levels in the building.
- ❖ For beam design is to the overloaded beam. The beam with long span is the design beam.
- ❖ Column is the overloaded column.

- Foundation is one that supports the designed column.
- Stairs are the same type at all levels. We have to design one of those stairs.
- Compressive strength of concrete is 30N/mm2 and tensile strength of steel is 460N/mm2 and 250 N/mm2 for stirrup.
- Cover to reinforcement considerations are; 25mm for Beam and slab, 25mm for Column, 50mm for Foundation.
- Thickness: plaster30mm, tiles 50mm
- General loading conditions: Roof (Imposed):1.5 KN/m2, Floor (Imposed) 4kN/m2, floor (Finishes) 2KN/m2, Stairs (Imposed) :4kN/m2
- Other relevant information: Self weight of Reinforced concrete 25kN/m3, Self-weight of masonry wall 20kN/m3, self-weight of plaster 15 kN/m3
- Fire resistance: 1hour for all elements.
- Modulus of elasticity of concrete Ec=2*104Mpa

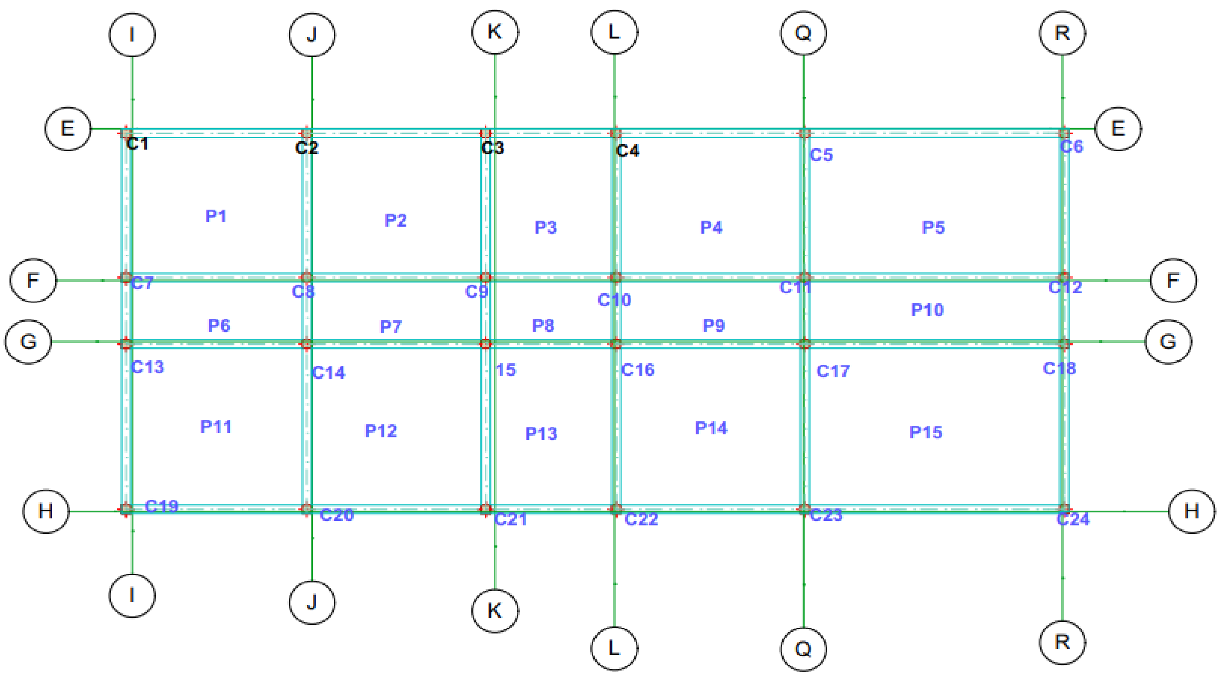


Figure3. 1. Slab design

Slabs are plate elements forming floor sand roofs in buildings which normally carry uniformly distributed loads.

Reinforced concrete slabs are used in floors, roofs and walls of building and as the decks of bridges. The floors systems of the structures can take many forms such as in situ slabs, ribbed slabs or precast units slabs may span in one direction or in two directions and they may be supported on monolithic concrete beams, steel beams, walls or directly by the trues.

4.2.1 Calculation of depth of slab

From B8110-1:1997 table says that maximum modification factor should be less or equal to 1.5

$minimuneffectivedeth = \frac{\text{span}}{26*\text{modification factor}}$

And $\frac{Ly}{40}$< h <$\frac{Ly}{30}$, $\frac{6200}{40}$= 155 , $\frac{4700}{30}$= 156.6, Therefore 155< h < 156.6

Then, dmin = $\frac{6200}{26*1.5}$= 158.97mm, So taking d=150 mm, assume the steel diameter to be 12mm, and cover to be 25 , h= d + cover + $\frac{Ø}{2}$ = 150+25 +12/2 = 181mm let us 180mm

Thickness of the slab lies in the range between

11.75 hf 23.5 let us take hf =15cm

Effective height ho=Thickness of the slab – the clear cover ho = 15cm-2.5cm=12.5cm

4.2.2 Calculation of loads

Self-load= 1.4*1*1*0.15*24kN/ m=5.04kN/m

Finishes= 1.4*1*1*1.5*2 kN/m=4.2 kN/m

Dead load =5.04KN/m+4.2kN/m=9.24kN/m

Calculation of live load

Live load= (1.6*1*1*2) KN/m=3.2kN/m

Live load =3.2kN/m

Total load on slab (p) = (9.24+3.2) kN/m=12.44kN/m

4.2.3Design of moments and shears

$\frac{Ly}{Lx} \leq 2$

Ly = 6.2m Lx = 4.70m

$\frac{Ly}{Lx}=\frac{6.2m}{4.70m}$= 1.3≤2, so we have two way slab.

(We have two ways slab)

$Msx^{+}=Bsx^{+}*n*lx^{2}$

$Msx^{-}= Bsx^{-} *n*lx^{2}$

$Msy^{-}=Bsy^{-}*n*lx^{2}$

$Msy^{+}=Bsy^{+}*n*lx^{2}$

As we have Let take 1.4

Msy^{+} =0.034*10.34*4.7^{2}=7.766kNm

Msx^{+}=0.053*10.34*4.7^{2}=12.106kNm

Msy^{-}=0.045*10.34*4.7^{2}=10.278kNm

Msx^{-}=0.072*10.34*4.7^{2}=16.446kNm

M-max=18.50kNm

M+max=8.68kNm

Design of steel reinforcement at the top

M-max= 18.50kNm

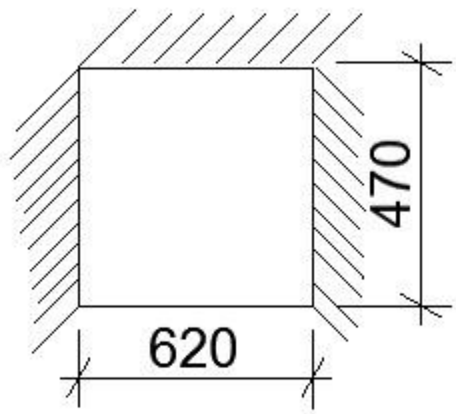


Figure3. 2. Critical panel 11

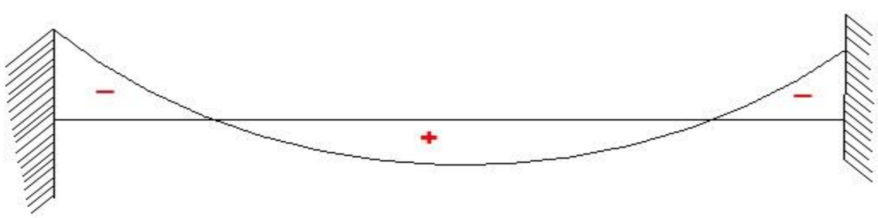


Figure3. 3. Moment of the slab panel

Let us take 6ϕ10/m with AS=4.71 cm2

Space between bars= = 20cm

Design of steel reinforcement at the bottom

M KNm

=0.042 let us take 0.049

=0.05; ξ< R=0.393 (Case of singly reinforcements) η=0.975

$A_s = \frac{M}{ho*\eta*Rs} = \frac{8.68*100}{12.5*0.975*40} = 1.780cm^2$

Let us take 6ϕ8/m with A_S=3.02 cm

Space between bars=$\frac{100}{(6-1)}$ = 20cm

Steel bars arrangement

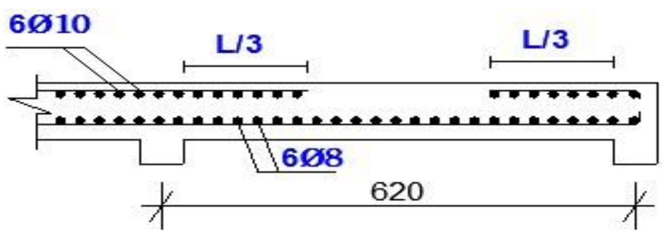


Figure 5: Steel bars arrangement

4.3. Beams design

4.3.1. Design of beam

2-2 (Most loaded longitudinal internal beam)

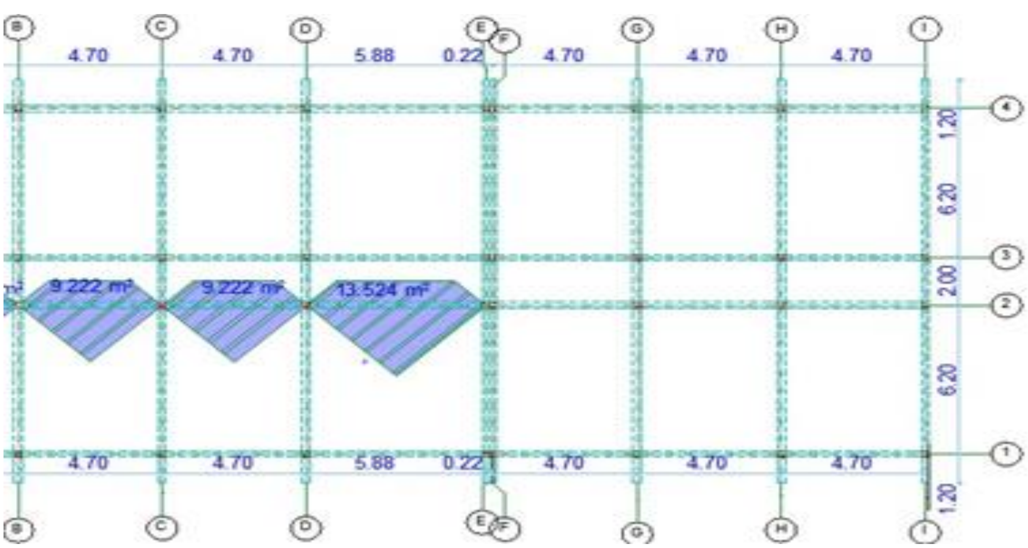


Figure4. 1. Loading area on the beam

The beam can be analyzed and designed using coefficients method or Prokon software can be used. The choice for the analysis and design of this beam is the use Prokon software.

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

The overall depth of the beam (h) lies within the following interval.

Where: Lmax is the largest span between two Consecutive beams

For this beam Lmax is equal to520cm which will give

Then 49cm 73.5cm

Let's take h =65cm for this beam the breath is ranging in the interval of which is from 21.66cm to 32.5cm. In line with the above assumption, let's takes b = 30cm 2.1.3. Computation for the breath of the flange (bf) bf for T beam is equal to the smallest value of the following:

12hf +b=12*15cm+30cm = 210cm

So, the bf of the beam will be 196cm

The height of the wall masonry =3.55m-0.65m=2.90m

The height of the area of the plaster=3.55m-0.15m=3.4m

Additional loadings on the beam (self-weight is computed by the software but non factored)

Non- factored own weight of the beam = {24*[(1.96*0.15) +(0.30*0.65)]} = 11.736 kN/m
Factored own weight of the beam= 1.4*11.736= 16.430kN/m
Beam own weight deference = Factored own weight of the beam minus Non- factored own weight of the beam i.e.: 16.430kN/m – 11.736 kN/m = 4.694kN/m

Wall load: 1.4*0.2*2.90*1*19= 15.428kN/m
Wall finishes: 1.4*0.03*3.4*20*2 = 5.712kN/m
Subtotal dead load: (15.428+5.712+4.694) = 25.834 kN/m

Load from the slab:

- Self-weight of the slab = 1.4*1*1*0.15*24 = 5.04 kN/m^2
- Slab Finishes = 1.4*1*1*1.5= 2.1 kN/m^2

Dead load from the slab = 5.04+2.1= 7.14 kN/m^2

Uniformly distributed live loads (kN/m) = 1.6*1*1*2= 3.2 kN/m^2

Table4. 1. Shows characteristic strength of the beam

Fcu (MPa)	25
Fy (MPa)	450
Fyv (MPa)	250
% Redistribution	0
Downward/Optimized redistr.	D
Cover to centre top steel(mm)	40
Cover to centre bot.steel(mm)	40
Dead Load Factor	1.4
Live Load Factor	1.6
Density of concrete (kN/m3)	24
% Live load permanent	25
Ø (Creep coefficient)	2
Ecs (Free shrinkage strain)	300E-6

Where:

- ✓ Fcu: is the characteristic concrete cube strength.
- ✓ Fy: is the characteristic strength of reinforcements
- ✓ Fyv: is the characteristic strength of link reinforcements

Table4. 2. Section input parameters

Sec No.	Bw (mm)	D (mm)	Bf-top (mm)	Hf-top (mm)
1	300	650	1960	150

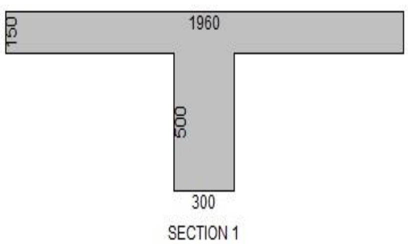


Figure4. 2. Beam section

Table4. 3. Shows spans and their loads

Case D,L	Span	Wleft (kN/m)
D	1	36.934
D	2	39.844
D	3	39.844
D	4	42.374
L	1	4.976
L	2	6.278
L	3	6.278
L	4	7.414

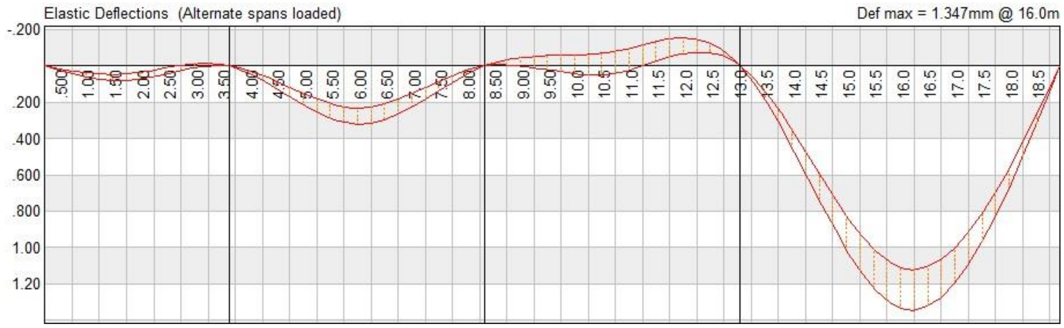


Figure4. 3. Elastic deflection of beam

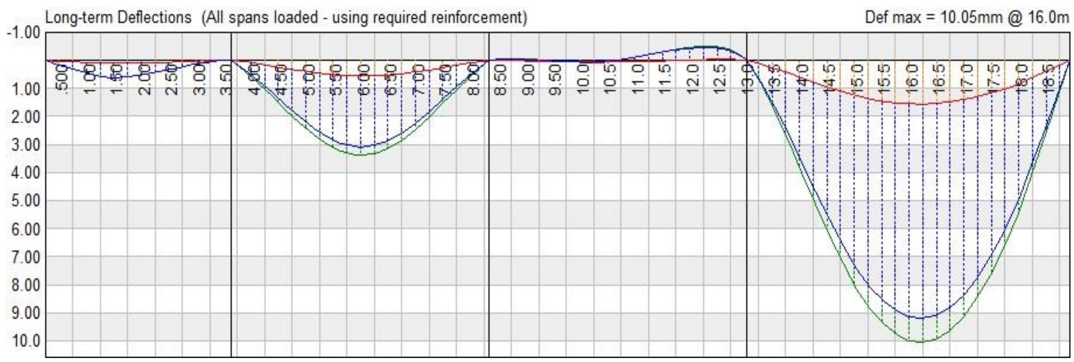


Figure4. 4. Long-term deflection of the beam

The ultimate deflection $f_u = \frac{Lmax}{500}$

$f_u = \frac{5880}{500} = 11.76$ m

The maximum long- term deflection should be lesser than the ultimate deflection for suitable beam; otherwise the depth of the beam can be changed. For the beam 2-2 the maximum long-term deflection is 10.05mm which is lesser than the ultimate deflection fu=11.76mmthus the beam cross sectional. Dimensions are suitable.

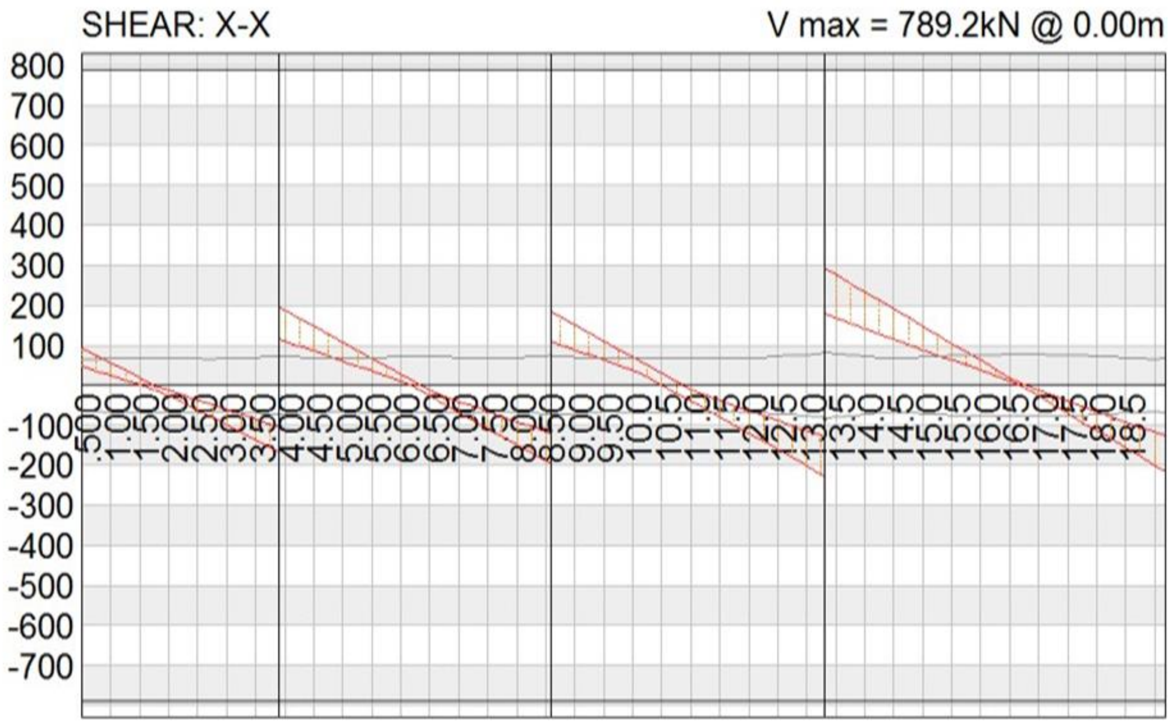


Figure4. 5. Shear force diagram

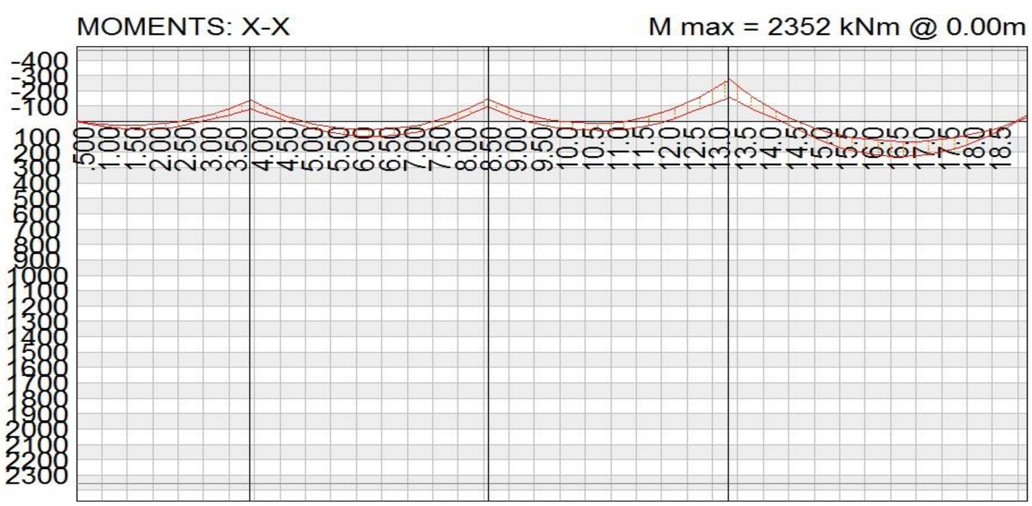


Figure 1: Bending moment diagram

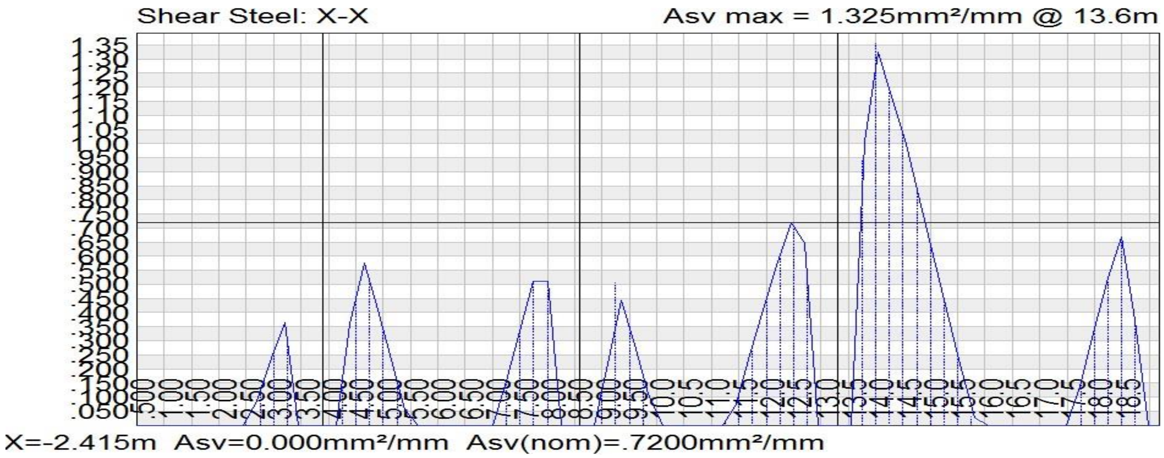


Figure4. 6. Shear reinforcement

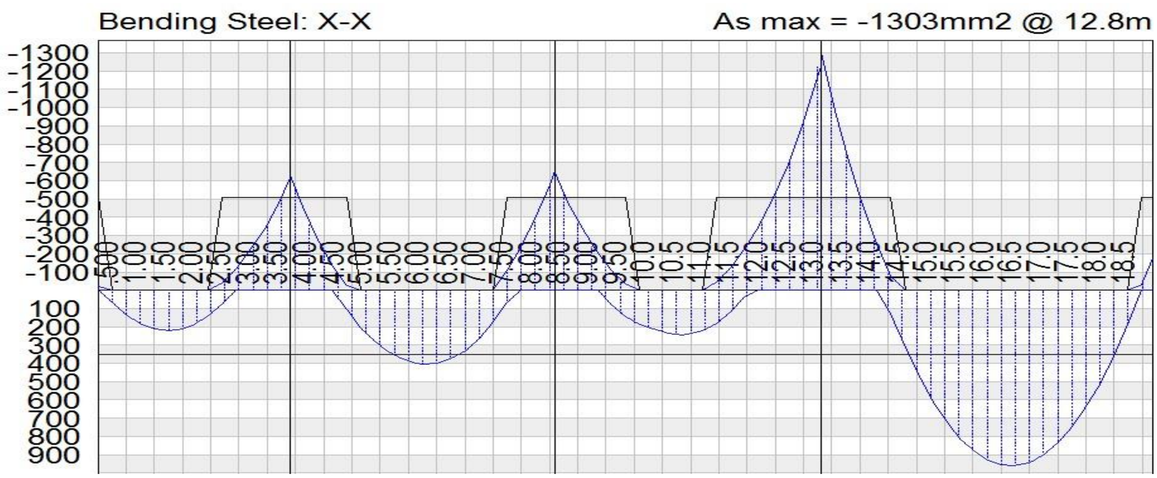


Figure4. 7. Bending reinforcements

- The Asv = 1.325 mm^2/mm = 13.25mm^2/mm which gives the use of links of minimum Asv = 50.2 mm^2/cm of Φ8.
- The area of required steel reinforcement at the top As max = 1303mm^2 which gives the use of 5Φ20of As = 1571mm^2
- `The area of required steel reinforcement at the bottom As max = 959.5mm^2 which gives the use of 5Φ16of As = 1005mm^2

Table4. 4. Link reinforcements spacing

Stirrup Number	Spacing	Span	Offset	Length (m)
14	200	1	0.25	2.80
21	200	2	0.25	4.20
21	200	3	0.25	4.20
4	300	4	0.25	1.20
19	200	4	1.70	3.80

Let's consider 200mm for stirrups spacing.

Longitudinal cross section of the beam.

Section A-A

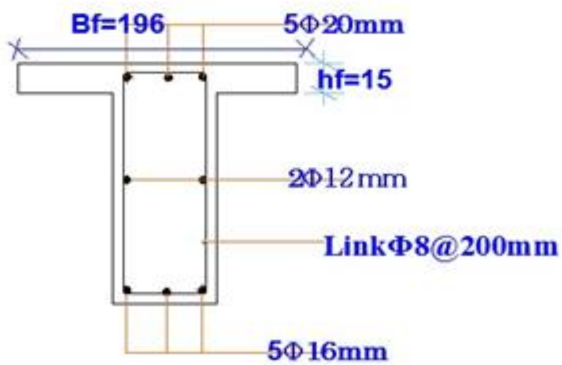


Figure4. 8. Steel arrangement in the beam

4.3.2. Column design

Consider the C16

Load calculations

Calculation of dead load

The height of the wall masonry=3.55m-0.65m=2.90m

The height of the area of the plaster=3.55m-0.15m=3.4m

Self-load of column/m= (1.4*0.30*0.30*1*24) kN=3.02kN/m

Load from the slab = (7.14*4.1*4.7) KN=137.59kN

Load from the Plaster=1.4*0.03*3.4*(4.1+4.7) *2*20*kN= 50.26kN

Load of Masonry wall=1.4*1*0.20*(4.1+4.7) *2.9*19*kN=135.77kN

Load from the beam =1.4*1*0.30*0.30(4.1+4.7) *24*kN=26.61kN

Calculation of live load

Live load=2*(4.1*4.7) =38.54kN

GROUND FLOOR PART OF THE COLUMN

N1= [(137.59+50.26+135.77+26.61+38.54)

*3+3.02*15.35+137.59+26.61+38.54]kN =1415kN

1st FLOOR PART OF THE COLUMN

N2= [(137.59+50.26+135.77+26.61+38.54) *2+3.02*11.8+137.59+26.61+38.54] kN =1016kN

2nd FLOOR PART OF THE COLUMN

N3= [(137.59+50.26+135.77+26.61+38.54) *1+3.02*8.25+137.59+26.61+38.54]KN=616kN

3rd FLOOR PART OF THE COLUMN

N4= [3.02*4.7+137.59+26.61+38.54] kN=216.9kN

Slender ratio

=8.3 let us take 8

Table4. 5. Shows the value of φ

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

Using table, we saw that φ= 0.91

Steel reinforcement on ground floor part of the column

$$As=\frac{\frac{N}{\varphi}-Ab*Rb}{Rs}=\frac{\frac{1415}{0.91}-\frac{1.3}{1}*30*30}{1*40}=9.62cm^2$$

Let us take 4ϕ18withAS=10.18cm^2/m

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

In this case we have [(10.18*100)/900] %=1.131% the steel reinforcement is (OK)

Steel reinforcement on 1st floor part of the column

$$As=\frac{\frac{N}{\varphi}-Ab*Rb}{Rs}=\frac{\frac{1016}{0.91}-\frac{1.3}{1}*30*30}{1*40}=-1.34cm^2$$

Let us take 4ϕ12 with AS=-4.52cm^2/m

Steel reinforcement on 2nd floor part of the column

$$\frac{\frac{}{\varphi}-Ab*Rb}{Rs}=\frac{\frac{216.9}{0.91}-\frac{1.3}{1}*30*30}{1*40}=-23.29cm^2$$

$$As=\frac{\frac{}{\varphi}-Ab*Rb}{Rs}=\frac{\frac{}{0.91}-\frac{}{1}*30*30}{1*40}=-12.33cm^2$$

Let us take 4ϕ12withAS=4.52cm

Steel reinforcement on 3rd floor part of the column

$$As=\frac{\frac{N}{\varphi}-Ab*Rb}{Rs}=\frac{\frac{216.9}{0.91}-\frac{1.3}{1}*30*30}{1*40}=-23.29cm^2$$

Let us take 4ϕ12withAS=4.52cm

The diameter of links should not be less than 6mm or one-quarter of the size of the largest compression bar. $\geq\frac{18}{4}=4.5 let$ take ϕ6

Stirrup spacing

The maximum spacing should be l2 times the size of the smallest compression bar.

Spacing<12*12=14.4cm, let us take spacing=140mm and stirrup= ϕ6

Steel arrangement in column

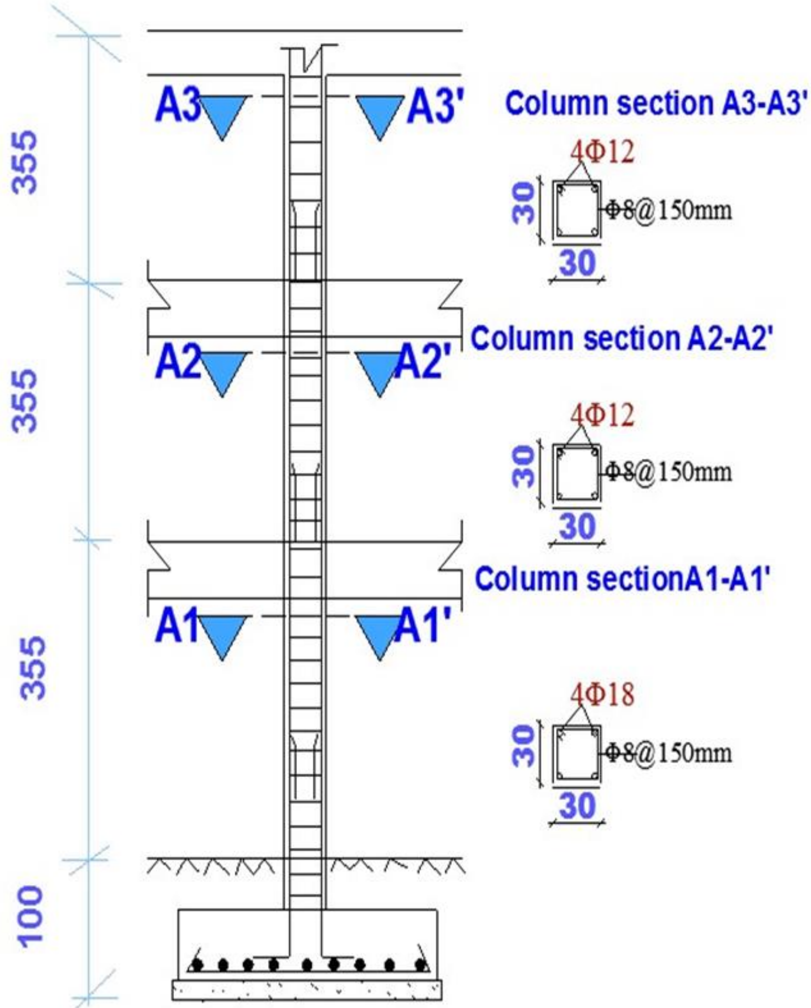


Figure4. 9. Steel arrangement in column

4.4. Design of pad foundation for the column

Loading C16

Column design load=1415kN

Total design live load=38.54*4kN=154.16kN

Total design dead load=1415kN -154.16kN=1260.84kN

Total characteristic live load=154.16kN/1.6=96.35kN

Total characteristic dead load=1260.84kN /1.4 =900.6kN

Total characteristic load=900.6kN +96.35kN =996.95kN

Estimated foundation weight +soil on it=996.95*10%=99.695kN

Total load on the soil=996.95kN +99.695kN =1096.645kN

This project has proposed to be done on the soil that has high cohesiveness, so the value of that soil should be lay between 300kN/m^{2}and 600kN/m², so that the chosen value bearing capacity was 350kN/m².

Bearing capacity of soil=350kN/m^2

Af=1096.645KN /350kN/m^2

=3.13m2=177*177cm

Let us take 190cm x 190cm

DESIGN SOIL PRESSURE (P)

P=1415/190*190cm^2=0.039KN/cm^2

Horizontal distance from the column to the edge of foundation is

(190-30) cm/2=80cm

Let us take the thickness of foundation of 55cm   h0=55cm- 5m=50cm

By considering the inclination of 450, from the corner where column connects the foundation, going to the bottom of the foundation, we get the dimensions of the: 80cm -50cm=30cm

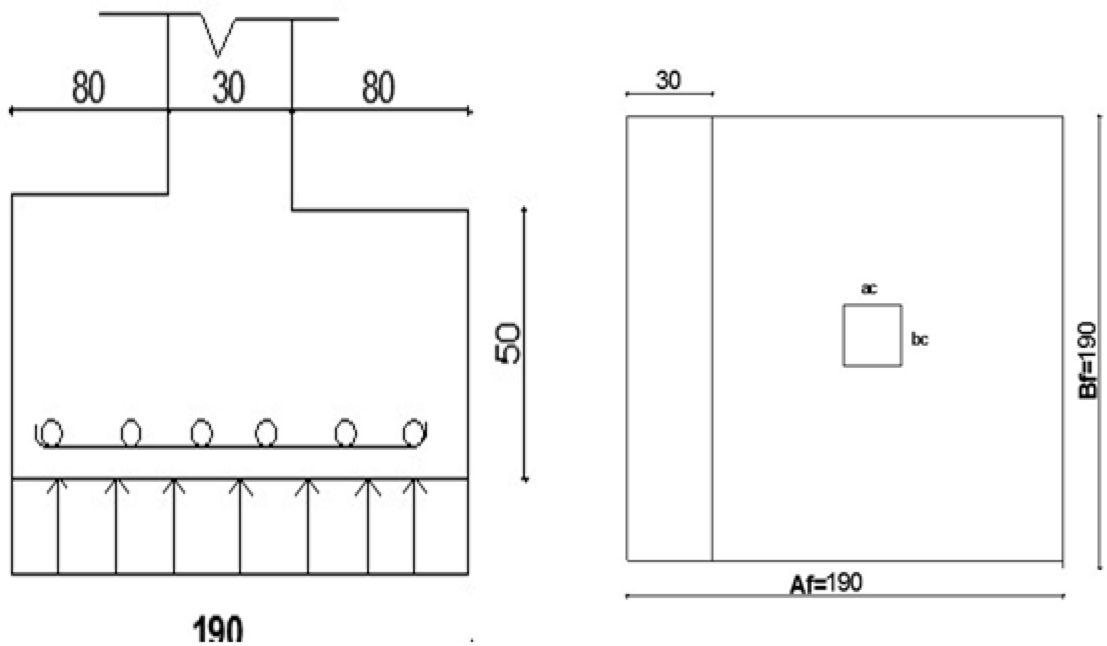


Figure4. 10. Section of foundation

Shears

$Q \leq 0.54*Rbt*Ab$

Q=P*bf*30=0.039*190*30=222.3kN

0.54*Rbt*Ab=0.54*0.09*190*30=277.23kN

Therefore, Q=222.3<277.23kN (the thickness is OK with this shear)

PUNCHING SHEARS (2nd trial)

$Qf=Nf-\Delta q \leq Rbt*Ab$

Ab=Um*ho

Um=2(ac+bc+2ho) =2(30+30+2*50) =320cm

$Ab=320*50=16000cm^2$

Δq=p (ac+2ho) (bc+2ho) =0.039(30+2*50) (30+2*50) =659.1KN

$Qf = Nf-\Delta q \leq Rbt*Ab$

(1415-659.1) KN ≤0.09*16000

755.9KN ≤1440KN (the thickness is ok)

Thickness of the pad foundation must be of 55cm

BENDING MOMENT

$Mmax= (P*af /2) *[(bf -bc)/2]^2= (0.039*190/2) *[(190 -30)/2]^2 KNcm$

Mmax=23712KNcm

STEEL BARS CALCULATION

$AS=\frac{M}{0.9*ho*Rs}==\frac{23712}{0.9*50*40}=13.17cm^2/m$

Let us take 8ϕ16/m with AS=16.08cm/m

Steel arrangement in footing

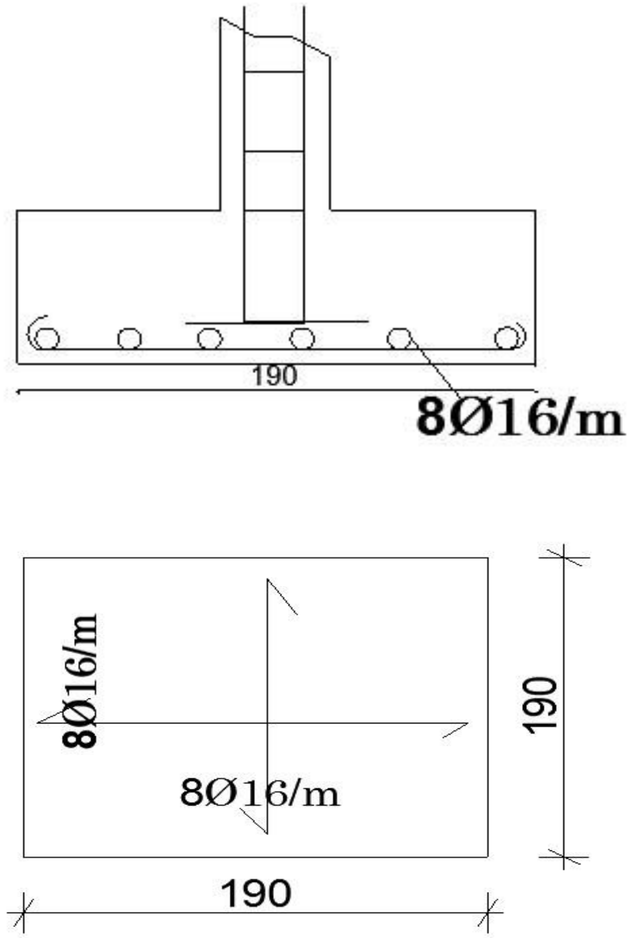


Figure4. 11. Reinforcement in footing

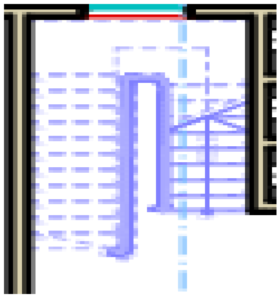


Figure4. 12. Stair case design

Assume arise H=16cm 2H+B=60-64

B= 64-2*16=32cm

Angleα= tan-1 16/32=26.60 =270

dl= dl=17.75cm

(17.75, 11.83) let take dl=15cm

Thickness =   =24.8cm =25cm

h0=25-2.5=22.5cm

4.5. Load on outside landing

Dead load= 1.4*0.225*1*1*24kN/m3 = 7.55kN/m

Finishing = 1.4*1.5*1*1 = 2.1kN/m2

Live load =1.6*4 =6.4 kN/m^2

Total load= 6.4 +2.1+= 7.55=16.05 kN/m^2

Landing

Dead load=1.4*0.15*1*24=5.04kN/m

Live load=1.6*2=3.2kN/m

Finishes=1.4*1.5*1*1=2.1kN/m

Total=10.34KN/m

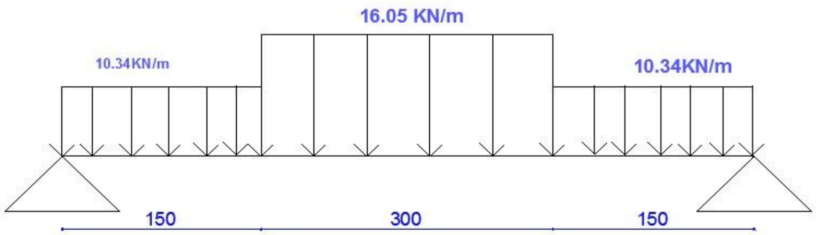


Figure4. 13. Loads on stair

Fy =AY+BY (10.34*4) +(16.05*4) =105.6kN

$\alpha m = \frac{M}{ho^2 * b * Rb} = \frac{105.6}{(22.5)^2 * 100 * 1.3} = 0.16$

ξ=0.18 η=0.910

Steel bars calculation

$A_s = \frac{M}{ho * Rs * \eta} = \frac{105.6 * 100}{22.5 * 40 * 0.910} = 12.89 cm^2/m$

Let use 6ϕ8with corresponding as=14.07cm^2/m

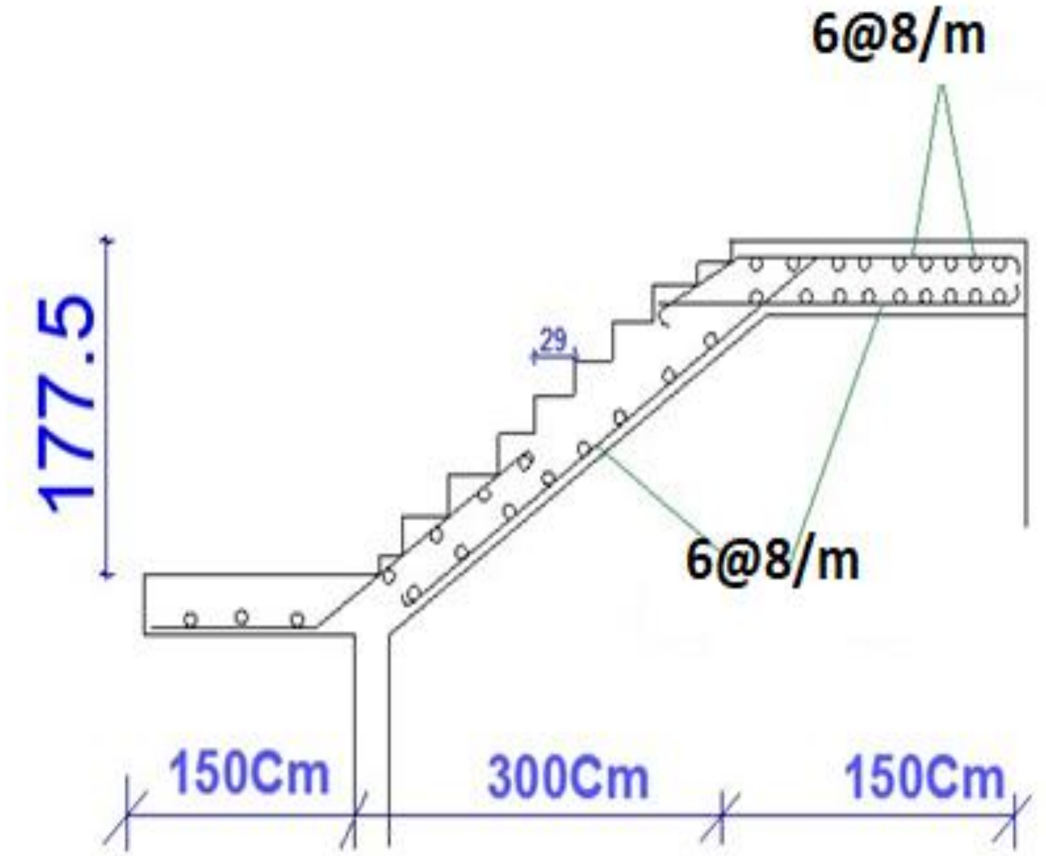


Figure4. 14. Reinforcement in stair

CHAPTER FIVE: CONLUSION AND RECOMMENDATION

5.1. CONCLUSION

In this study, you have seen how to build multi-storey construction that successfully connects great spaces with healthy financial returns. There are a number of options the hotel industry can take to become more sustainable; from simple measures like implementing a towel and linen reuse program to using sustainable materials and strategies from the ground up in a new build.

According to the details of architectural and structural design of multi-storey building, the structural components in a typical multi-storey building, consists of a floor system which transfers the floor loads to a set of plane frames in one or both directions.

The floor system also acts as a diaphragm to transfer lateral loads from wind or earthquakes. The frames consist of beams and columns and in some cases braces or even reinforced concrete shear walls as a height of a building increase it becomes necessary to reduce the weight of the structure for both functionality and economy. This means that the columns in the lower storey will become smaller leading to more availability of space and further reduction in the foundation design.

5.2. RECOMMENDATIONS

In line with this present project, we were meet with intricate work for using software in the design of some structure elements, so that I would like to recommend to our department to increase how the students of Civil engineering can get well the sufficient requirement trainings about the use of software also I would like to recommend to the planning authorities and government to do the following:

- To make the idealization about construction of multi-storey buildings especially hotels in different sectors of this district in order to achieve sustainable tourism and land use management.
- I would also recommend the young brothers in civil engineering to study hard about software's like Archcad and Prokon because it will help them to finalize the project on time.

REFERENCES

B.D. NAUTIYAL. (2001). *Introduction to Structural Analysis.*Mumbai: K.K Gupta.

Choi, K.-K. (2002). *Reinforced Concrete Structure Design.*

Choi, K.-K. (2002). *Reinforced Concrete Structure Design.*

Diener, M. L., & Parekh, A. (2008). *Sustainable.* Califonia.

Eden. (2003). *The Architecture.* Poltland: New Jervey.

F., & Morgan, W. (2010). *Structure Design.* New York: Khanna.

Harris, R. (1996). *Dictionary of Travel&Tourism Hospitality Term.* J.Macdonald, A. (1997). *Building Materials.*

K.Hari, P. R. (2011). *Concrete Structural Analysis.*

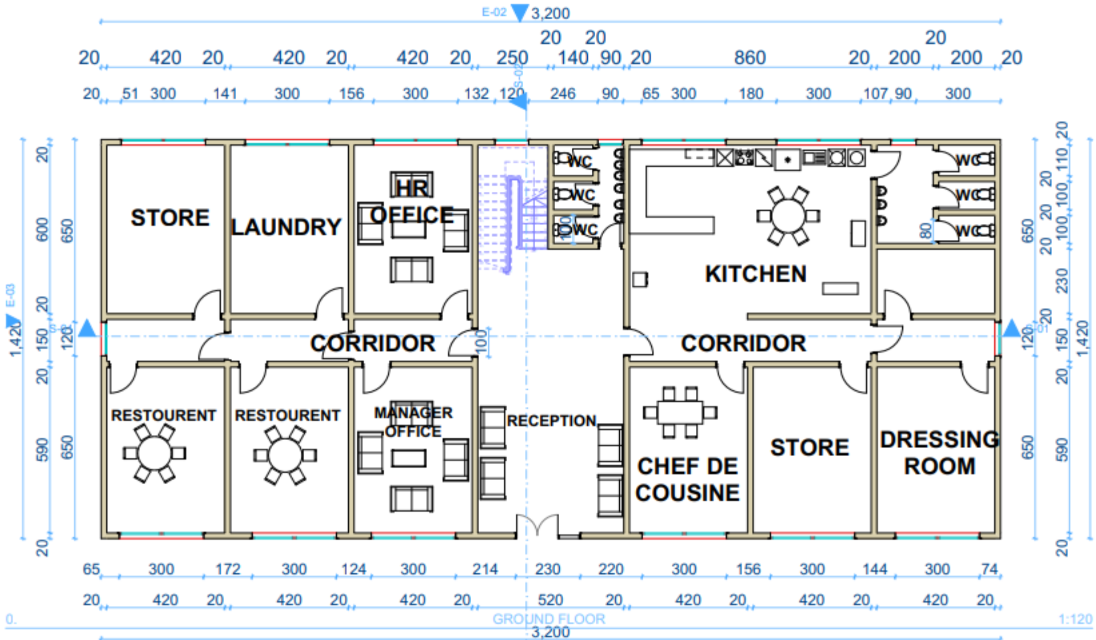
Kumar, B. R. (2011). *Structural Analysis Design.* New York.

Macdonald&, D. A. (1994). *Structure and Architecture.* London: ButterworthHeinemann.

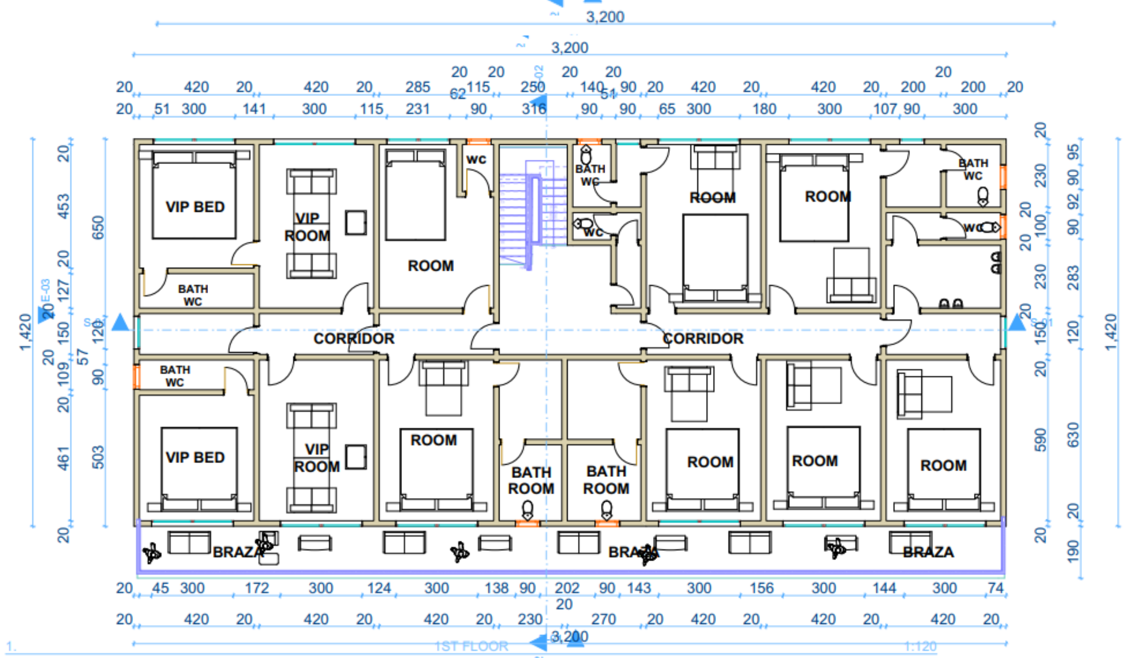
Macdonald, D. A. (1994). *Reinforced Conrete Design.*

Schierle, G. (2002). *Reinfoced Concrete Structural Design.* Delmar

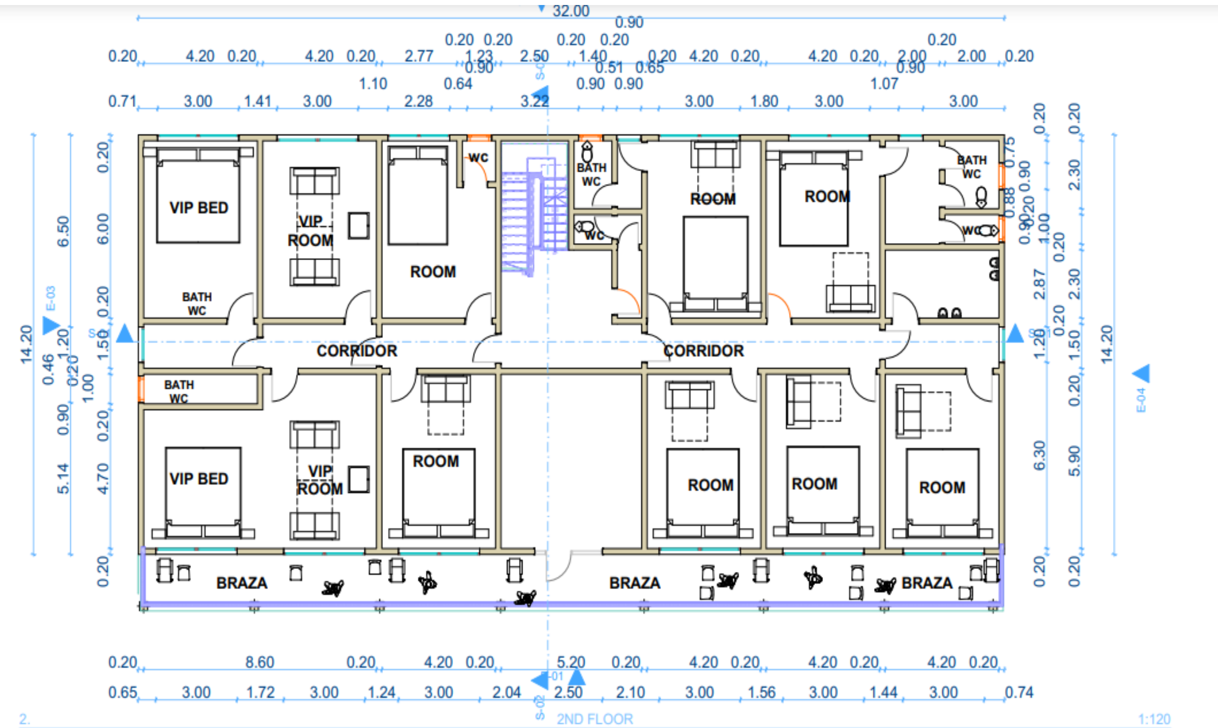
Appendices



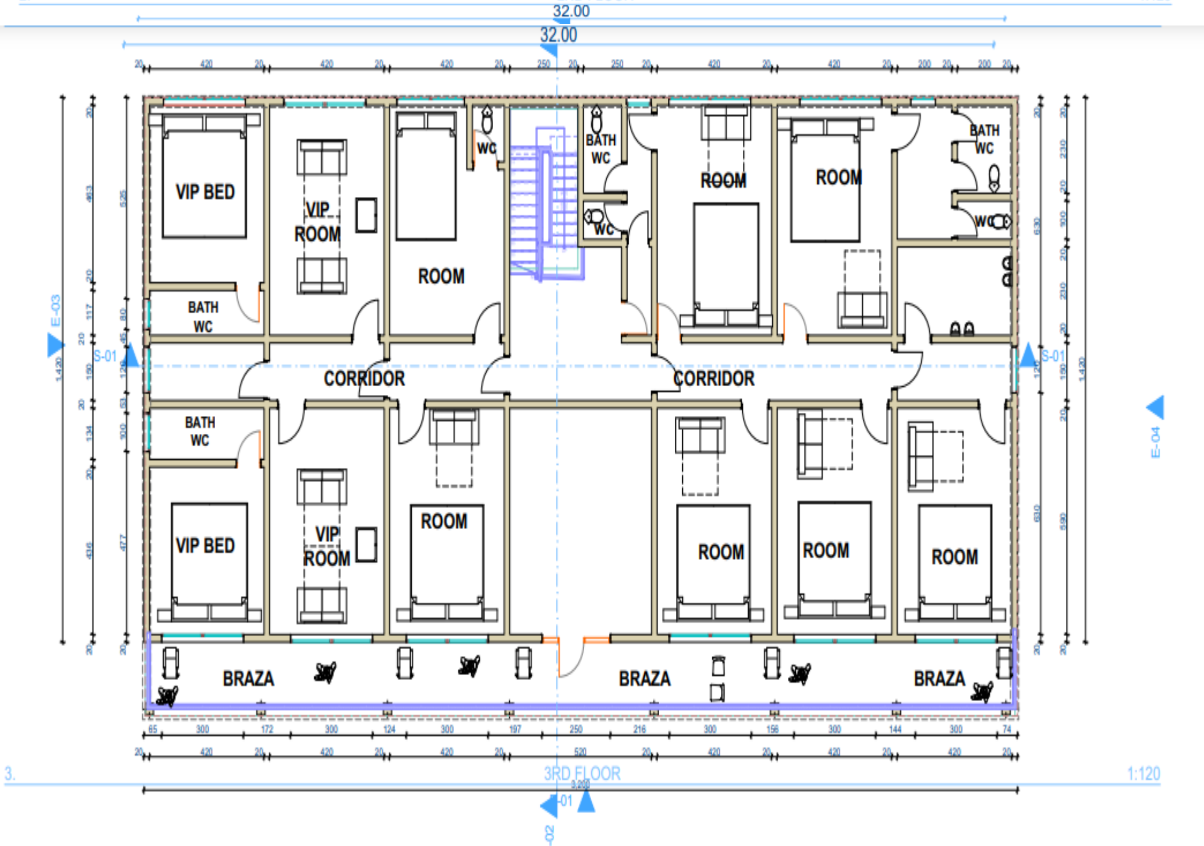
STORE
LAUNDRY
HR OFFICE
WC
WC
WC
KITCHEN
WC
WC
WC
CORRIDOR
CORRIDOR
RESTOURENT
RESTOURENT
MANAGER OFFICE
RECEPTION
CHEF DE COUSINE
STORE
DRESSING ROOM
GROUND FLOOR
1:120



VIP BED
VIP ROOM
ROOM
WC
BATH WC
ROOM
ROOM
BATH WC
WC
WC
BATH WC
CORRIDOR
CORRIDOR
BATH WC
VIP BED
VIP ROOM
ROOM
BATH ROOM
BATH ROOM
ROOM
ROOM
ROOM
BRAZA
BRAZA
BRAZA
1ST FLOOR
1:120



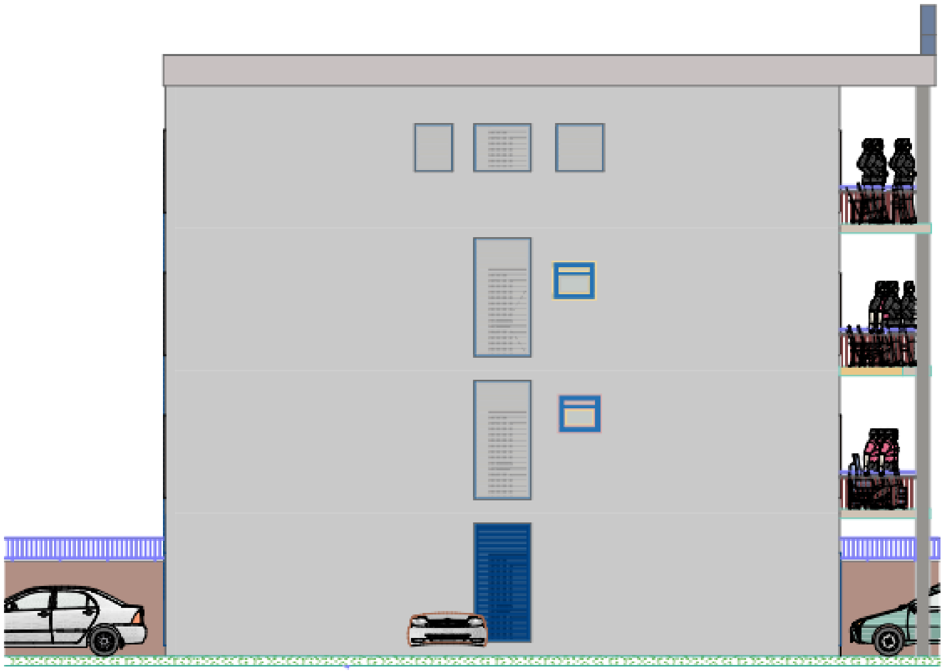
VIP BED
VIP ROOM
ROOM
WC
BATH WC
ROOM
ROOM
BATH WC
CORRIDOR
CORRIDOR
BATH WC
VIP BED
VIP ROOM
ROOM
ROOM
ROOM
ROOM
BRAZA
BRAZA
BRAZA
32.00
14.20
2ND FLOOR
1:120



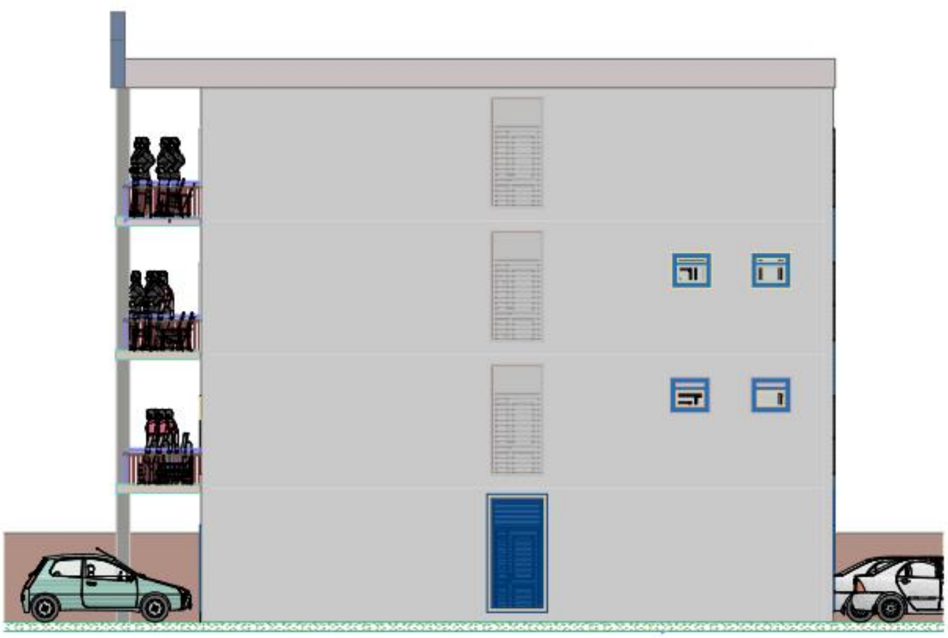
VIP BED
VIP ROOM
ROOM
WC
BATH WC
ROOM
ROOM
BATH WC
BATH WC
CORRIDOR
CORRIDOR
BATH WC
VIP BED
VIP ROOM
ROOM
ROOM
ROOM
ROOM
BRAZA
BRAZA
BRAZA
32.00
3RD FLOOR
1:120


E-01
FRONT Elevation
1:100

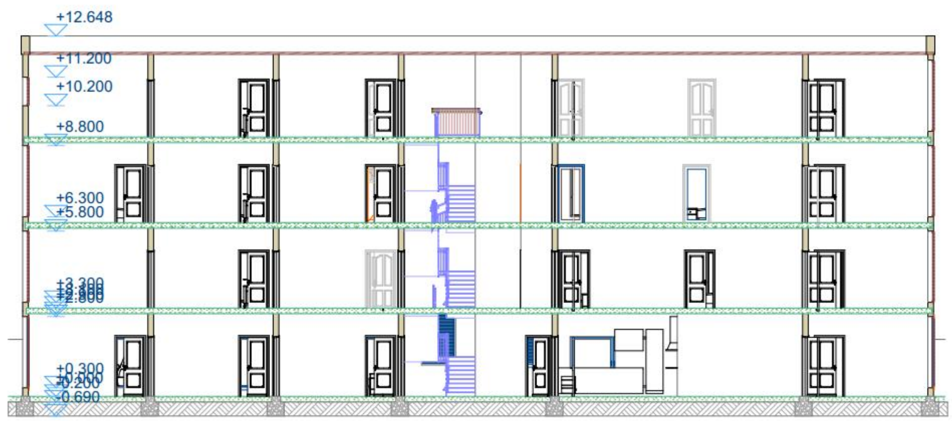

E-02
BACK Elevation
1:100



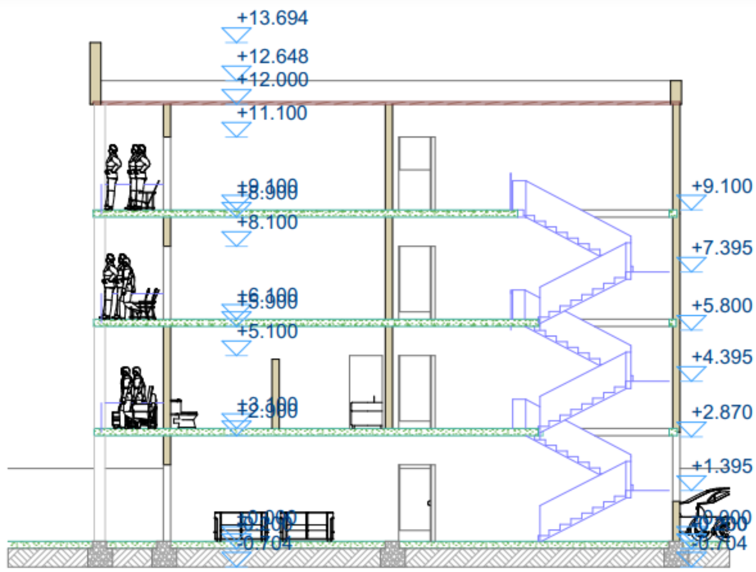
E-03 LEFT Elevation 1:100



E-04 RIGHT Elevation 1:100



S-01 LONGITUDINAL Section 1:100



S-02 CROSS Section 1:100