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DECLARATION OF ORIGINALITY

I DIALLO CHERIF MOCTAR do here by declare that the work presented in this dissertation entitled “Architectural and structural design of G+4 Residential and Commercial Building at Kigali city, Gasabo district, Gisozi sector” is my own contribution to be the best of my knowledge. The same work has never been submitted to any other University or Institution. I, therefore declare that this work is my own for the partial fulfillment of the requirements for the Advanced Diploma (A1) in construction Technology at ULK Polytechnic Institute.

The candidate’s name: DIALLO CHERIF MOCTAR

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

Date of submission …………………………………………………

APPROVAL

This is to certify that this dissertation work entitled Architectural and structural design of G+4 Residential and Commercial Building at Kigali city, Gasabo district, Gisozi sector is an original study conducted by DIALLO CHERIF MOCTAR have been submitted with the approval of supervisor under his guidance.

The supervisor’s name: ……………………………………

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

Submission date …………………………………………….

DEDICATION

I would like to dedicate this work:

To the Almighty God who give opportunity in life to complete our study.

To my parents

ULK Polytechnic Institute administrative staff

To my supervisor

I greatly dedicate this work to everyone contributed directly or indirectly to my tasks.

ACKNOWLEDGEMENTS

My deep gratitude goes to my supervisor, ……………………………for his tireless supervision and guidance in the writing of this dissertation. My appreciation goes ULK Polytechnic Institute and its various departments especially Civil Engineering (Advanced Diploma A1) department and lectures for the knowledge they gave me during my study. I am very thankful to all members of my family especially my lovely parents and my beloved brothers and sisters for their consistent and valuable support and advices to bring me up both morally, economically and not forget their financial accordance to me right from primary to university level. I also express my gratitude to everyone who directly and indirectly contributed to make my dissertation period successful today. All the people that surround me every day I just appreciate. Finally, I extend my lovely appreciation to the Almighty God, to whom I acknowledge all the writing of this project.

ABSTRACT

The general objective of this research was to conduct an Architectural and structural design of G+4 Residential and Commercial Building at Kigali city, Gasabo district, Gisozi sector. It is the reason why this research has been conducted to solve that problem. Different methods have been used for well conducting this study such as analytical method for designing different structural members like slab, beam, column, foundation, stairs and shear wall, different software's has been used like ArchiCAD 19, for providing architectural drawing of the Residential and Commercial Building such including all plan views, sections, elevation and perspectives, ETABS have been used for the structural design of beam, stair and shear wall by computing beam detailing. Prokon has been used for the design of footing. This proposed building has total area of 797.5m2 with width of 27.5 m and length of 29 m, story height is 3.1m each. Bill of quantity has been calculated within this study the results showed that the designed steel reinforcements to be arranged in slab were at the top 10@200mm and 10@200mm at the bottom while for T beam designed steel reinforcements were 5Φ16 at the top and 4Φ16 at the bottom. And for column the designed steel reinforcements were 12Φ20. For the stair designed steel reinforcement were 12@250mm for main, a shear wall design steel reinforcement was for longitudinal 12@200mm. The building was well located therefore the expected result have been achieved. this project has been estimated to the cost of 1,159,206,705 Rwf. The execution of this project would stimulate proper land use, solve the problem of continuous demand of plot of land for Residential and Commercial Buildings, which could be used for other human development activities.

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LIST OF ABREVIATION

A: Cross Sectional Area

As: Cross sectional area of tensile reinforcement

As': Cross sectional area of compression reinforcement

As min: The minimum required area of the reinforcement

B: Width of the member

Bw: web width of a flanged beam

bf: breadth of section (for a flanged beam this should be taken as the average width of the flange).

Gk: Dead load

h: The overall depth of the member

hf: The overall depth of the flange

ho: Effective depth of the cross section

Lx: Short span length

Ly: Long Span length

M: Bending moment

M+x: Design moment from the bottom at the shorter side

M+y: Design moment at the bottom of the longer side

αm, ɳ: The ratio of the lever arm to the effective depth of the cross section.

P: Total design load per unit area

N: design axial load

Qk: characteristic imposed Load

Gk: characteristic dead load

Fcu: characteristic yield strength of concrete

Fy: characteristic [2] yield strength of reinforcement

Fyv: characteristic yield strength of links (not to be taken as more than 460N/mm2)

R: Rise

Rb: Design concrete compressive strength

Rs: Design steel tensile strength

Rbt: Concrete design tensile strength

Rsw: Design strength of stirrups

X: Depth of the neutral axis

Φ: The diameter of the reinforcement

αm: Coefficient taking into account the bending moment action

Asv: Area of steel in vertical links

B.S: British Standard

RC: Reinforced concrete

BOQ: bill of quantity

kN: Kilo Newton

Q: Shear force acting on the cross section

Qf: punching shear force

qsw: Total shear force carried by the all legs of stirrup

Dl: Difference between long span and short [2] span of the beam

Δq: Balancing shear force

S: Distance between stirrups

LIST OF APPENDICES

CHAPTER 1: GENERAL INTRODUCTION

1.1. Background of the study

Residential and Commercial Building is [18] a commercial establishment offering lodging to travelers and sometimes to permanent residents, and often having restaurants, meeting rooms, stores, etc., that are available to the general public. Rwanda is a developing country in all economic sectors, as far as economic growth is concerned Rwanda is receiving different foreign people coming in for different services in those service there is a Residential and Commercial Building need for shelter, meetings, restaurant services, etc. according to the vision 2050 of Rwanda which is Urbanization and Agglomeration (Sainaghi, 2010).

In this goal [21] focus will be on identifying and creating synergies between the critical elements of urbanization that create agglomeration and enhance the socioeconomic benefits of urbanization. 14 Urbanization will continue to rapidly change with new growth poles projected to emerge besides the already planned six secondary cities and Kigali city due to large investments being undertaken for example in Gasabo district.

7 Building construction is the engineering deals with the construction of building such as residential houses, school building, Residential and Commercial Building, etc. Simply, building can be defined as an enclose space by walls with roof, 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, the humans being started living in huts made of timber branches. The shelters of those ancient humans have been developed nowadays into beautiful houses. Rich people live in advanced or qualified houses. Buildings are the important indicator of social progress of the country (Fanella, 2011).

For that also Gasabo district has planned that a part of Gisozi sector is reserved for the Residential and Commercial Building s activities due to its strategic way to the schools & Universities and even to other areas within the district as far as Gasabo district development is concerned. For this reason I came up with the idea of this project of architectural and structural design of a Residential and Commercial Building in Gisozi sector, because there is less Residential and Commercial Building in this region according to populations and it will be highly needed because of rapid development of Gasabo district and many activies that will be hold there in the coming days and because the Residential and Commercial Buildings in the whole district is in small number compared to the needed.

1.2. Problem statement

The shortage of Residential and Commercial Buildings in Gasabo district as it is a developing district and Rwanda is developing as well, it is facing the problem of inefficient Residential and Commercial Building services because the number of people coming in there needing the 9 Residential and Commercial Buildings is greater than the number which the Residential and Commercial Buildings there are capable of holding. To avoid this problem there is the need of carrying out the project of architectural and 13 structural design of a Residential and Commercial Building in Gisozi sector as the solution of this problem and as the Provision of urbanization development in general.

1.3. Objectives

1.3.1. General objective

The general objective of this project was to provide the architectural and structural design of a Residential and Commercial Building in Gisozi sector in Gasabo district.

1.3.2. Specific objectives

1.To work out the architectural drawings

2.To design structural elements of the building

3.To provide the bill of quantities of this building.

1.4. Research questions

1.How was the architectural design?

2.What code was used in analyzing structural members and 13 the structural design of this project?

3.What was the bill of quantity for this project?

1.5. Justification of the study

The design of buildings involves many design variables. The design codes for buildings is exceptionally difficult to interpret, it takes to dig enough in research and to get familiar with them. The building reflects the progress in the economic development of the country, so working on this project is much like being in service to the society. In the long run, this project is also a part of leaning.

1.6. Significance of the study

1.6.1. Personal significance

This project will help to put in practice what we have studied in theory and will help to know different software's that are used in design 32 at the end of this project, we will be able and eligible to design, supervise and construct sustainable buildings as well.

1.6.2. Institutional Significance

Once this proposal of project is accepted, it will also be considered as reference in term of Civil engineering document to other studies [32] and at the end of the project after defense this dissertation will be as reference to next generations which will be carrying out final year projects.

1.6.3. Public Significance

Achievement on the implementation of this proposal of project will help people with provision of increased infrastructures and then Rwandan government can use this information’s to protect public infrastructures built that endangers public safety and decrease the amount of money spent while rebuilding damaged different infrastructures.

1.7. Study delimitations

This study will be conducted on the architectural and [13] structural design of a Residential and Commercial Building. The limitations will be on plumbing, electrical installation, lab test of waste water, lift design and the geotechnical data will be secondary not primary data.

1.8. Methodology and materials

In implementing this study, the architectural design will be carried out using ArcCAD19. After the architectural design, the analysis and design of the structural elements will be done by the help of ETABS by taking into account Rwanda building code and other building standards codes registered in application. The study literacy will be conducted through Microsoft word and excel, internet, books according to ULK Polytechnic Institute final year dissertation guidelines.

1.9. Organization of the study

This research has made up with five chapters. Chapter one which is the general introduction, it guides the reader to get idea of what study is all about. This chapter contains the background of study, statement of problem, objectives of project, delimitation of research and summary of methodology was used. Chapter two is the literature review; it outlines reviews on architectural and structural design basic concepts and theories related to specific objectives. Chapter three is methods and techniques which describe methodology (materials and methods) used in study and study area. Chapter four is results and discussions which presents structure analysis and design followed by relevant discussions. Chapter five is conclusion and recommendations. It closes the report by providing a brief overview of the content in the report and indicates the overall findings of the study, its significance and advantages of information presented. Recommendations also made in this chapter and then references and appendices are also added.

CHAPTER 2. LITERATURE REVIEW

2.1. Philosophy of designing

The structure [3] design of any structure first involves establishing the loading and other design conditions, which must be supported by the structure and therefore must be considered in its design. This is followed by the analysis and computation of internal gross forces, (i.e., shear, bending moment), as creep and other design conditions. Finally comes the proportioning and selection of materials for the members and connections to respond adequately to the effects produced by the design condition (Park & paulary, 1991).

2. 2. Building codes and standards

In the design and construction field, the codes and standards impact modern building construction and are constantly changing, and it is difficult at best to keep up with copious changes and how they impact building design. For engineers and architects who is working with structural design. The aim of design is the achievements of an acceptable probability that the structures being design perform a satisfactory durability during their intended life. 15 With an appropriate degree of safety, they should sustain all the loads and deformation of normal construction and use and have adequate durability and resistance to the effects of misuse and fire (Cochran & Derickson, 2011).

The British concrete institute standard, building code requirements for reinforced concrete, has permitted the design of a reinforced concrete structure in accordance with limit state principles using load and resistance factors since1963. A probabilistic assessment of these factors and implied safety levels is made, along with consideration of alternate factors values and formats Working stress principles and linear elastic theory formed the basis for reinforced concrete design prior to 1983, when the concept of ultimate strength design was incorporated in the BS building code Because of the highly nonlinear nature of reinforced concrete behavior, the linear approach was unable to provide a realistic assessment of true safety levels (Cochran & Derickson, 2011).

2.3. Architectural drawings

Architectural drawing is the special language if the architecture used to convey the client impressions of how a contemplated building would appear when completed? It is also used to convey to the 4 contractors and workmen who perform the work of erection the information regarding size, form, materials, dimensions, etc. necessary to enable them to estimate the probable cost of the building and to erect the building as the architecture conceives it in his/her own mind (Pickard, 2003).

1 An architectural drawing or architect's drawing is a technical drawing of a building (or building project) that falls within the definition of architecture. Architectural drawings are used by architects and others for a number of purposes: to develop a design idea into a coherent proposal, to communicate ideas and concepts, to convince clients of the merits of a design, to assist a building contractor to construct it based on design resolved, as a record of the design and planned development, or to make a record of a building that already exists (Pickard, 2003).

Historically, drawings were made in ink on paper or similar material, and any copies required had to be laboriously made by hand. The twentieth century saw a shift to 7 drawing on tracing paper so that mechanical copies could be run off efficiently. The development of the computer had a major impact on the methods used to design and create technical drawings, making manual drawing almost obsolete, and opening up new possibilities of form using organic shapes and complex geometry. Today the vast majority of drawings are created using CAD software (Pickard, 2003).

2.3.1. Working Drawing

Working drawings, also called suitable [17] for construction drawings (GFC), are drawings that will also help provide the architect with detailed, dimensioned, graphical information that a contractor must use to construct the works or by suppliers to fabricate components of the results. [4] Must be as complete and accurate as possible, every line, mark, letter and numeral must have a definite meaning so that exact estimates of the cost of the work can be made and so that the building can be properly erected from the drawings (Ferguson, 1988).

2.3.2. Scale Details

After the working drawing have been completed and specification which describe the work to be done on the building have been written, the architect proceeds to make scale details, which are drawings of certain parts of the building at a larger scale than used for the working drawing The scale of drawings is described as a ratio using the notation: A distance at full size: The distance at the scale used that would be the same length. [28] For example: A full size drawing would be 1:1 (Ferguson, 1988).

2.3.3. Plans

The plan of any object is the view of it as seen from above. In the case of buildings, there may be several plans. These are horizontal sections, or cuts taken through the building, one at each storey, showing the building as it might appear with the upper parts removed. [11] Plans are a set of drawings or two-dimensional diagrams used to describe a place or object, or to communicate building or fabrication instructions. Usually plans are drawn or printed on paper, but they can take the form of a digital file. The arrangement of walls, partitions, doors and windows, stairs, etc (Park, 1975).

1 A site plan is a specific type of plan, showing the whole context of a building or group of buildings. A site plan shows property boundaries and means of access to the site, and nearby structures if they are relevant to the design. For a development on an urban site, the site plan may need to show adjoining streets to demonstrate how the design fits into the urban fabric. Within the site boundary, the site plan gives an overview of the entire scope of work. It shows the buildings (if any) already existing and those that are proposed, usually as a building footprint; roads, parking lots, footpaths, hard landscaping, trees and planting. For a construction project, the site plan also needs to 8 show all the services connections: drainage and sewer lines, water supply, electrical and communications cables, exterior lighting etc (Park, 1975).

Site plans are commonly used to represent a building proposal prior to detailed design: drawing up a site plan is a tool for deciding both the site layout and the size and orientation of proposed new buildings. A site plan is used to verify that a proposal complies with local development codes, including restrictions on historical sites. In this context the site plan forms part of a legal agreement, and there may be a requirement for it to be drawn up by a licensed professional: architect, engineer, landscape architect or land surveyor (Park, 1975).

2.3.4. Elevations

An elevation is a view of a building seen from one side, a flat representation of one façade. This is the most common view used to describe the external appearance of a building. Each elevation is labelled in relation to the compass direction it faces, e.g., looking toward the north you would be seeing the southern elevation of the building. Buildings are rarely a simple rectangular shape in plan, so a typical elevation may show all the parts of the building that are seen from a particular direction. Geometrically, an elevation is a horizontal orthographic projection of a building onto a vertical plane, the vertical plane normally being parallel to one side of the building. Architects also use the word elevation as a synonym for façade, so the "north elevation" is the north-facing wall of the building (Krishna, 2007).

2.3.5. Section

Sections are cuts through the building made by vertical planes, these drawing shows the elevations of the interiors of the various rooms and stairs, together with cuts or sections through the foundation, floors, walls, and roofs. A section is a very useful drawing, as it gives information that cannot be shows in an elevation or a plan. A cross section, [1] also simply called a section, represents a vertical plane cut through the object, in the same way as a floor plan is a horizontal section viewed from the top (Milligan, 1984).

In the section view, everything cut by the section plane is shown as a bold line, often with a solid fill to show objects that are cut through, and anything seen beyond generally shown in a thinner line. Sections are used to describe the relationship between different levels of a building. In the Observatories drawing illustrated here, the section shows the dome which can be seen from the outside, a second dome that can only be seen inside the building, and the way the space between the two accommodates a large astronomical telescope: relationships that would be difficult to understand from plans alone (Milligan, 1984).

2.4. Structure elements

2.4.1 Foundation

It is the building’s substructure below ground. [6] The foundations transfer and spread the loads from a structure’s columns and walls, into the ground. The safe bearing capacity of the soil must not be exceeded otherwise excessive settlement may occur, resulting in 21damage to the building and its service facilities or affect the overall stability of a structure. The general design procedure involves assessment of the soil bearing pressure, examination of levels around the structure (bearing strata, water). Calculation of transmitted loads and moments, calculation of the required plan and then the required foundation depth and provided (Salgado, 2008).

2.4.1.1. Shallow foundation

The design footing, including the amount [2] of reinforcement and the type of footing employed, is highly dependent on the type of structure being erected as well as the soil condition. The substructure, also known as the foundation, is the section of the structure that sits beneath the ground surface and transfers the load to the soil beneath it. Because soil is significantly weaker and more flexible than structural materials (concrete and soil), it can withstand loads above the soil pressure and deformation (settlement) within permissible limitations (without harming the superstructure) (Teodosio et al, 2019).

2.4.1.2. Deep foundation

Deep foundation is required to carry loads from a structure through weak compressible soils or fills on to stronger and less compressible soils or rocks at depth, or for functional reasons. Deep foundations are founded too deeply below the finished ground surface for their base bearing capacity to be affected by surface conditions, this is usually at depths >3 m below finished ground level. Deep foundation can be used to transfer the loading to a deeper, more competent strata at depth if unsuitable soils are present near the surface. Piles or piers are long, slender components buried deep in the ground. A deep foundation is used when a typical shallow foundation fails due to soil conditions such as sand or other unstable soil (Teodosio et al, 2019).

2.4.2. Columns

A column is a compression member, which is used primary to support axial compressive loads and with a height of at least three it is least lateral dimension. Depending upon the architectural requirements and loads to be supported, R.C columns may be cast in various shapes i.e. square, rectangle, and hexagonal, octagonal, circular. Columns of L shaped or T shaped are also sometimes used in multi-storeyed buildings. The longitudinal bars in columns help to bear the load in the combination with the concrete. The binders prevent displacement of longitudinal bars during concreting operation and also check the tendency of their buckling towards under loads. The column is indicated in the figure below (Keller & Niordson, 1966).

Figure 1: Column

2.4.3. Beams

[2] A beam is a structural element that primarily resists loads applied laterally to the beam's axis (an element designed to carry primarily axial load would be a strut or column). Its mode of deflection is primarily by bending. The loads applied to the beam result in reaction forces at the beam's support points. The total effect of all the forces acting on the beam is to produce shear forces and bending moments within the beams, that in turn induce internal stresses, strains and deflections of the beam. Beams carry lateral loads in roofs; Floors and resist the loading in bending, shear and bond. The design must comply with the ultimate and serviceability limit states. Detailed analysis and design of reinforcement; serviceability calculations. The beam section may be singly reinforced or doubly reinforced (Hajjar, 1996).

2.4.3.1. Simply supported beam

[2] A simply supported beam is one that rests on two supports and is free to move horizontally. Although for equilibrium, the forces and moments cancel the magnitude and nature of these forces, and the moments are important as they determine both stresses and the beam curvature and deflection Simply supported beams are those that have supports at both end of the beam. These are most frequently utilized in general construction and are very versatile [9] in terms of the types of structures that they can be used with. A simply support beam has no moment resistant at the support area and is placed in a way that allows for free rotation at the ends on columns or walls. The [2] simply supported beam is indicated in the figure below (Burke& Hubbard, 1987).

Figure 2: Simply supported beam

2.4.3.2. Continuous beam

A continuous beam is one that has two or more supports that reinforce the beam. These supports are used under and between the beams and are typically vertical in nature.

Continuous beams are thought to be more economical when compared to other beam types. A beam resting upon several supports, which may be in the same horizontal plane. A beam having several spans in one straight line; generally, has at least three supports The continuous beam is indicated in the figure below (Burke & Hubbard, 1987).

Figure 3: Continuous beam

2.4.3.3. Cantilever beam

2 A cantilever beam is one that is free-hanging at one end of the beam and fixed at the other. This type of beam is capable of carrying loads with both bending moment and sheer stress and is typically used when building bridge trusses or similar structures. The end that is fixed is typically attached to a column or wall. The tension zone of a cantilever beam is found 3 at the top of the beam with the compression at the bottom of the beam. A cantilever beam is a rigid structural element that is supported at one end and free at the other. The 2 cantilever beam can be made of either concrete or steel whose one end is cast or anchored to a vertical support. It is a horizontal beam structure whose free end is exposed to vertical loads. The cantilever beam is indicated in the figure below (Barten, 1944).

Figure 4: Cantilever beam

2.4.3.4. Fixed beams

A fixed beam is one that is fixed on both ends of the beam with supports. This type of beam does not allow for bending moment production and will not have any vertical movement or rotation. Fixed beams are most frequently used in trusses and similar structures. A fixed beam is supported between two fixed ends. It is also called fixed-end beam or built-in beam or restrained beam. It is classified as a statically indeterminate beam, which involves more than three unknowns and the equilibrium equations of statics alone are not sufficient to determine the support reactions. The fixed beam is indicated in the figure below (Barten, 1944).

Figure 5: Fixed beam

2.4.3.5. Overhanging beams

An overhanging beam is one that is supported at two different areas, typically at one end and in the middle of the beam, but does not have a support at the other end of the beam, leaving it hanging. This type of beam extends beyond the walls or columns and the overhanging [2] section of the beam is unsupported. An overhanging beam is a combination of a simply supported beam and a cantilever beam. Overhanging beam are defined as the types of construction beams whose end portion of the beam extends beyond the supports. The properties of the overhanging beams are same as the cantilever beam and simply supported Beams. The overhanging beam is indicated in the figure below (Barten, 1944).

Figure 6: Overhanging beam

2.4.4. Slab

Slabs are plate elements forming floors and roofs in buildings which normally carry uniformly distributed loads. Slabs may be simply supported or continuous over one or more supports and are classified according to the method of support as follows: Spanning one way between beams or walls, spanning two ways between the support beams or walls, Flat slabs carried on columns and edge beams or walls with no interior beams, Stairs with various support conditions form a special case of sloping slabs. Concrete slabs behave primarily as flexural members and the design is [3] similar to that for beams, although in general it is somewhat simpler. Continuous slabs should in principle be designed to withstand the most unfavorable arrangements of loads in the same manner as beams. The slab is indicated in the figure below (Clarke, 1984).

Figure 7: Slab

2.4.5. Stairs

Stair must be provided in almost all buildings, either low-rise building even if adequate numbers of elevators are provided. Stairs consist of rises, runs (or treads) the total steps and landings are called a staircase. The rise is defined as the vertical distance between two steps, and the run is the depth of the step. The landing is the horizontal part of the stair Buildings or bridge structures are erected for a purpose. The first requirement is that the buildings and bridges be designed to optimally suit this purpose (Blanc, 2012).

To meet the specific purpose, a bridge may have different structural types: arches, beams. The structure should reveal itself in a pure, clear form and impart a feeling of stability. They seek simplicity here. Reinforced concrete is a composite material of steel bars surrounded in a hardened concrete matrix. Concrete assisted by the steel carries the 22 compressive forces, concrete is itself a composite material, and is the dry mix consists of cement and coarse and fine aggregate. Water is added and this reacts with the cement that hardens and binds the aggregates into the concrete matrix (Blanc, 2012).

The usual form of stairs can be classified into two types: those spanning horizontally in the transverse direction, those spanning longitudinally Stairs of this type may be supported on one side by a wall and on both sides and they may be cantilever from a supporting wall (Blanc, 2012). The stair slab may span landing which spans at the right angle to the stair. The Effective depth of the member is taken as the mean effective depth of the section and the main reinforcement must be placed in the top of the stairs and anchored into the support. A light mesh of reinforcement is placed in the bottom face to resist shrinkage cracking. The stair is indicated in the figure below (Blanc, 2012).

Figure 8: Stair

2.4.6. Roof

The roof is the uppermost component of a structure that protects it from rain, wind, and sun. The different types of roofing that are utilized can be categorized into three categories: Roofs with flat surfaces, slanted roofs, Shells and folding plates. Flat roofs are used in plains where rainfall is less and climate is moderate. Pitched roofs are preferred wherever rainfall is more. Shells and folded plate roofs are used to cover large column free areas required for auditoriums, factories etc (Jayasinghe et al., 2003).

2.5. Material of construction

2.5.1. Concrete

Concrete is produced by mixing cement, fine aggregate, coarse aggregate with water and additional materials known as an admixture. The admixture is sometimes added to modify certain of its properties. Atypical mix would have the ratio of cement, sand, coarse aggregate to be 1:2:4 but it can be varied depending on the required strength (Woodson, 2011).

Concrete operations

This refers to the process involved in concrete from storage of some of its ingredients to it hardening stage but the stage of maintenance can be overlooked (Woodson, 2011).

The properties of steel reinforcement

For a strong, ductile and durability, the reinforcement shall have the following properties: High strength, high tensile strain, good bond to the concrete, thermal compatibility, durability in the concrete environment (Woodson, 2011).

Failures in concrete structures

Elastic deformation: The important of metals is almost invariably related to their loading bearing capacity in tension, compression and their ability to withstand limited deformation without fracture when a material and this internally acting force is called stress. When a material is in state of stress, its dimension would change. When the stress is tensile, the dimension would be the impact is to twist to the material. This change in dimension would be short. For shear stress the impact is to be twist to the material. This change in dimension is called strain and it is the ratio of the change in length to the original length. For the direct stresses action acting in tension or compression the ratio direct stress, λ to direct strain, € is equal to modulus of elasticity or young’s modulus (E)= (σ/€) (Wallace, 1994).

Ductile: It is when metals deform plastically at low values of tress and yield to a very considerable extent before fracture occurs. Other metals and alloys show little plastic yielding before fracture these metals are called brittle materials. Finish server decoration and practical function they improve appearance of the structure underneath and also prolong building life (Wallace, 1994).

Factors affecting failure: Failures in concrete structures can be selected to meet environmental or soil conditions where the concrete is to place. The minimum grade that should be used for reinforced concrete is grade 30. Higher grades should be used for some foundations and for structures near the sea or in an aggressive industrial's environment. If sulfates represented in the soil or groundwater. Sulfate resisting Portland cement should be used. Where freezing and throwing occurs air entrainment should be adopted (Wallace, 1994).

Stress-Strain relation: The loads on structure cause distortion of its members with resulting stresses and strains in the concrete and steel reinforcement. To carry out the analysis and design of a member, it is necessary to have the knowledge of the relationship between these stresses and strains Figure below shows a graphical representation of concrete behavior under load. It is produced by plotting concrete compress strain at various interval of concrete compressive loading stress. The Stress-strain curve for concrete in compression is indicated in the figure below (Wallace, 1994).

Figure 9: Stress-strain curve for concrete in compression

2.5.2. Brick materials

One of the oldest building materials bricks continues to be a most popular and leading construction material because of being cheap, durable, and easy to handle and work with Brick may be made of burnt clay or mixture of sand and lime or of Portland cement concrete. Soil bricks are used for building –up exterior and interior walls, partitions, piers, footings and other load bearing structures (Singh, 2019).

2.5.3. Stone materials

Stone has been used in the construction of most of the important structures since prehistoric age such as pyramids of Egypt, Great Wall of China. It has been defined as the natural, hard substance formed from minerals and earth material which are present in rocks. Stone can serve: to construct the foundation and wall items; to manufacture elements of stair, landing, parapets and guard rails and it can also be used as flooring materials (Singh, 2019).

2.5.4. Mortar materials

Mortar is a mixture of sand and lime or mixture of sand and cement with or without lime. The mortar used in brick work transfers the tensile, compressive and shear stresses uniformly between adjacent bricks. The mortar can also be used to join stone block (Singh, 2019).

2.6. Limit state design

2.6.1. Limit state

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. The two principal types of limit state are the ultimate limit state and the serviceability limit state. The ultimate limit states: This requires that the structure must be able to withstand with an adequate factor of safety against collapse, the loads for which it is designed. Serviceability limit states: generally, the most important serviceability limit state are: Deflection, Cracking, and Durability. The relative importance of each limit state would vary according to the nature of the structure. The use of partial factors of safety on materials and loads offers considerable flexibility, which may be used to allow for special conditions such as very high standards of construction and control or at the other extreme (Yan, 2019).

2.6.2. Partial factor of safety

Other possible variations such as constructional tolerances are allowed for by partial factors of safety applied to the strength of the materials and to the loading. In practice these values adopted are based on experience and simplified calculations (Saneinejad, 1995).

2.6.2.1. Partial factors of safety for materials

Design strength=Characteristic strength (fk)/partial factor of safety with fk = fm-64s, where fk=characteristic strength, fm=mean strength and s =standard deviation. The factors considered when selecting a suitable value for partial factors of safety for materials are: [3] the strength of the recommended values for partial factors of safety for materials are: the strength of the material in an actual member and the severity of the limit state being considered .The recommended values for partial factors of safety for materials are given in figure below although it should be noted that for precast factory condition it may be possible to reduce the value for concrete at [2] the ultimate limit state (Saneinejad, 1995).

Figure 10: Partial factors of safety for materials

2.6.2.2. Partial factors of safety for loads

Errors and inaccuracies may be due to a number of causes such as design assumptions and inaccuracy of calculation; possible unusual load increases; unforeseen stress redistributions and constructional inaccuracy. These cannot be ignored and are considered by applying a partial factor of safety on the loading so that design load=characteristic load x partial factor of safety. Where characteristic load = mean load =1.64 standard deviations the value of this factor should also take into account the importance of the limit state under consideration and reflect to some extent the accuracy with the each different types of loading can be predicted and the probability of particular load combinations occurring recommended values are given in table below (Leet, 2012).

2.6.3. Load combination for the ultimate state

According to (Chatterjee, 2008), various combinations of [25] the characteristic values of dead load (GK), imposed load (QK), wind load (WK) and their partial factors of safety must be considered for the loading of the structure. There as follow:

Dead and imposed load: 1.4 GK+1.6 QK

Dead and wind load: 1.0 GK + 1.4 WK

Dead, imposed and wind loads: 1.2 GK+1.2 WK.

2.6.4. Serviceability, durability and stability requirements

These requirements involve aspects of design, such as concrete mix selection and determination of cover to reinforcing bars as well as selection of suitable materials for the exposure conditions which are expected. In some circumstances deformations and cracking must be estimated. The design code specifies a set of basic spans [25] – effective depth ratio to control deflections for rectangular sections and for flanged beams with spans less than 10m with design rules. From that, an interpolation is used to estimate ratio for more lengths (Bartos, 2013).

2.7. Bearing capacity

Bearing capacity is the capacity of soil to support the loads applied to the ground without undergoing shear failure or excessive settlement. Foundation soil is that portion of ground that is subjected to additional stresses when foundation and superstructure are constructed. [19] The bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in the soil. The allowable bearing capacity is based on 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 (Loukidis, 2008).

2.8. Cost estimation

Cost estimation in project management is the process of forecasting the cost and other resources needed to complete a project within a defined scope. Cost estimation accounts for each element required for the project and calculates a total amount that determengineer a project budget. Cost Estimation is a statement that gives the value of the cost incurred in the manufacturing of finished goods. Cost estimation helps in fixing the selling price of the final product after charging appropriate overheads and allowing a certain margin for profits. It also helps in Inventory Reports drawing conclusions regarding the cost of production and in determining the necessity to introduce cost reduction techniques in order to improve the manufacturing process. (Gubic, 2019).

2.8.1. Bill of quantity

Estimating is the technique of calculating or computing the various quantities and expenditure to be incurred on a particular work or project. A cost estimate is a computation of many elements, an approximation of the probable quantity and unit cost of each of the elements A bill of quantities commonly known as BOQ or BQ is a document prepared by a quantity surveyor or cost consultant to define the quality and quantity of works required to be carried out by the main contractor to complete a project (Fanella, 2011).

2.8.2. Principles of Cost Estimation

1. Cost estimation is used to predict the quantity, cost and price of the resources required by the scope of a project. A project might be any process that is started to perform work activities and/or create assets. The accuracy of the estimate depends heavily on the level of project scope definition: as the design and conditions of the project become better defined, so do the estimated values (Ferguson, 1988).

2. Cost estimation is needed to provide decision-makers with the means to make investment decisions, choose between alternatives and to set up the budget during the front end of projects. For this, estimates made by vendors and contractors need to be validated by clients as well. In later phases of the project, the budget estimate is used as a baseline to assess the performance of a project (Ferguson, 1988).

3. Estimating is done by breaking down the total scope of a project in manageable parts, to which resources can be assigned and cost. There are standardized ways of breaking down a project, like the Work Breakdown Structure (WBS) and the Cost Breakdown Structure (CBS), but depending on the needs of the project team and external parties' multiple structures are often implemented to align reporting and sharing of cost data (Ferguson, 1988).

4. A cost estimate is more than a list of costs. It also includes a detailed Basis of Estimate (BOE) report that describes the assumptions, inclusions, exclusions, accuracy and other aspects that are needed to interpret the total project cost. Otherwise, it would be a meaningless number. The BOE is required to communicate the estimate to the various parties involved in the decision making but is also handy during closeout when the

performance of the project is compared with other projects. It is the vital part often overlooked, that allows you to learn from your experience and mistakes (Ferguson, 1988).

CHAPTER 3: MATERIALS AND METHODS

3.1. Introduction

This chapter describes different materials and methods used to successfully conduct this study. It starts by describing the case study and study area. Architectural and structural design procedures used are described here and the methods used for determining 25 the location of the building's foundation are shown in this chapter. The methods used for conducting the cost estimation of the proposed building are also highlighted in this chapter.

3.2. Case study description

The case study for the proposed 9 Residential and Commercial Building in Gasabo district in Gisozi sector. The building is a G+4 Residential and Commercial Building. The site is easily accessible from the road and has access to water and electricity. Gisozi sector is one of the 15 sectors of Gasabo district located in the Kigali city of Rwanda.

Figure 11.A: Site location of proposed Residential and Commercial Building

Figure 12.B: Site location of proposed Residential and Commercial Building

3.3. Architectural design

The architectural design of this building was done based on the standards specified in the

Rwanda building code. The design was done using a building information modelling (BIM) software known as ArchiCAD. This software was used to the preparation of architectural drawings including floor plans, elevations and sections and also the 3d model was exported from the software and imported into another software known as Twin motion for 3d rendering to obtain photorealistic images of the proposed Residential and Commercial Building (Madan, 1997).

3.4. Structural design

After the preparation of architectural drawings, Structural plans were prepared. The proposed structural plan for the building was composed of reinforced concrete columns, beams, slabs and stair. The structural design of this frame was done using a structural design software known as ETABS structural analysis where a structural model was drawn according to the structural plans and Prokon for the design of footing.

Multi-storied structures commonly feature prismatic sections, prevalent in developing countries, to effectively resist applied loads with minimal deformation between parts. The primary goal of structural design is to ensure the structure safely receives and transmits loads, while also achieving functionality, serviceability, feasibility, and aesthetics. The design process aims to make the structural elements efficient, elegant, and economical, considering both safety and economy. Reinforced concrete finds extensive use in various structures, such as bridges, buildings, tunnels, and more, due to its versatility, durability, fire resistance, and moldability. The design principles discussed here are applicable to any structure, provided information on axial force, shear, and moments along each member's length is available. For our multistory building, the design involves elements like slabs, beams, columns, and footings, combining them cohesively. By adhering to good construction practices, concrete proves to be a crucial and reliable building material.

3.4.1. Slab design

The design of slab was done by following the following condition and steps:

Slab panel choice

The design of slab was done firstly by choosing the critical panel which is the biggest panel

Slab thickness

The thickness of slab must lay between the panel $lx/20$ and $lx/40$ where lx is the shorter side of the panel

Slab thickness

Effective height (ho) = thickness of the slab- concrete cover

Loads calculation

Dead load: [22] the weight of the slab itself, as well as the weight of any permanent fixtures, partitions, and non-moveable elements of [34] the building, such as walls, columns, and mechanical systems.

Live load: temporary and variable loads caused by occupancy, furniture, equipment, and people moving within the building.

Bending moment calculation

Bending moment calculation was done by firstly determining if the slab is one way or two-way slab.

For the bending moment calculation, the following formulas were used:

Where λ is the ratio of the long side (ly) over the short side (lx)

Bending moment in the short span: $Mx = \alpha sx * n * lx2$

Bending moment in the short span: $My = \alpha sy * n * ly2$

Where n is the total [2] load on the slab

αsx and αsy: coefficient related to the designed slab.

Reinforcement calculation

To calculate the required reinforcement at the top and the bottom we have to know the required area of reinforcement, which are given by the formula below:

: Where $M-$ is the bending moment at the top

: Where $M+$ is the [3] bending moment at the bottom

3.4.2. Beam design

The beam design was done following these steps and condition:

Preliminary design

The preliminary design of the beam was done to find the various basic parameters of the beam which are the height, the breadth and the flange. Here down are the formulas and conditions that guided the preliminary design:

The total height (ht) of the beam has to be in the range below:

Where: Ly is the largest span between two consecutive beams.

The breadth of the section (width of the web bw) of the beam varies between

0.

The flange of (bf') of [3] the beam is to be the lesser of:

1.

2.

3.

Cross-section of the T-beam is assumed to be:

Loading

The following conditions were respected we can calculate the load on the beam using specific coefficients provided in the table 3.14 of the BS code Conditions:

a) Characteristic imposed load Qk may not exceed characteristic dead load Gk

b) Loads should be substantially uniformly distributed over three or more spans;

c) Variations in span length should not exceed 15 % of longest Dead load gk is the sum of:

-Weight of slab: slab thickness*slab width * unit weight of concrete

-Weight of down stand: bw* h * unit weight of concrete

-Finishes

Imposed load: characteristic imposed load * slab width

Design uniformly distributed load, W= (1.4Gk + 1.6Qk)

Design load per span, F= W*span

Table 4: Design ultimate bending moments and shear forces (Arya, 2022)

Reinforcement

After the ultimate bending moments and shear forces were found the reinforcements were calculated following these formulas:

-Effective depth (d) which is the distance from [2] the top surface of the beam to the centroid of the tensile reinforcement was found by using this formula:

-Lever arm factor (K) calculation:

Where:

Z: Distance from the centroid of the tensile reinforcement to the extreme fiber in compression of the beam's cross-section. d: Effective depth of the beam.

K: Lever arm factor, as explained in previous responses.

The expression essentially establishes a condition that the ratio of Z to d should meet in order to ensure the proper behavior of the beam under bending. This condition helps ensure that the tensile reinforcement and concrete work together effectively to resist bending moments and provide structural stability.

- Tensile reinforcement calculation

The expression below [2] is used to calculate the required amount of tensile reinforcement. This equation helps determine the appropriate size and quantity of reinforcement bars needed to safely carry the bending moments that the beam may experience during its service life.

Shear reinforcements

The amount and spacing of shear reinforcements depends on the area of tensile steel reinforcement present in the beam.

-Shear stress calculation:

Where:

Ʋ: represents the shear stress

V: denotes 3 the maximum shear force acting on the beam.

b: represents the width of the beam's cross-section. It's the horizontal dimension of the beam perpendicular to its length.

d: This represents the depth (or height) of the beam's cross-section. It's the vertical dimension of the beam.

-Shear capacity

The expression represents a formula 2 used to calculate the critical shear stress in a reinforced concrete beam. This formula is often employed 10 in structural engineering to assess the shear capacity of a beam's cross-section.

-Shear range check

(Ʋc + 0.4) < Ʋ <

This expression helps ensure that the shear stress within the beam's cross-section falls within a safe and acceptable range.

Ʋc: This represents the critical shear stress, which is the shear stress at which the beam is expected to experience failure due to shear forces. It's 2 an important design parameter for shear analysis.

Ʋ: This is the actual shear stress that the beam experiences due to applied loads. It's calculated based on the external loads, beam dimensions, and other factors. fcu: This is the compressive strength of the concrete used in the beam.

* (Ʋc + 0.4) < Ʋ

This condition ensures that the calculated shear stress (Ʋ) is greater than a certain minimum value, which includes the critical shear stress (Ʋc) plus an additional margin of safety (0.4). It's important 10 to ensure that the actual shear stress exceeds this lower limit to prevent shear failure.

*Ʋ < 0.8√(fcu)

This condition sets a maximum allowable shear stress (Ʋ) based on the square root of the compressive strength of the concrete (fcu). It's critical to ensure that the shear stress does not exceed this upper limit to prevent overstressing the beam's capacity.

-check for deflection

Basic span/effective depth ratio for a rectangular or flanged beam = 20.8

This ratio serves as a reference for evaluating the adequacy of the span-to-depth ratio in the design.

Calculation of modification factor

Where:

MF: This represents the modification factor for tension reinforcement. It adjusts the nominal strength of the beam to account for the actual behavior of the reinforcement under load.

fs: This is the design shear stress in the beam. It's a measure of the shear forces experienced by the beam due to applied loads.

M: This denotes the maximum bending moment that the beam is expected to experience.

b: This represents the width of the beam's cross-section, measured horizontally perpendicular to the beam's length. d: This is the effective depth of the beam.

Check the Permissible Effective Span/Depth Ratio

Depth ratio for a rectangular or flanged beam = 20.8 Permissible Effective Span/Depth Ratio = Depth ratio*MF Calculate Actual Span/Depth Ratio:

Actual span/depth ratio = lx / d Span/Depth Ratio Comparison:

If the calculated actual span/depth ratio is less than the permissible ratio the span-to-depth ratio is within acceptable limits.

3.4.3. Column design

The design of column was done by computing the most loaded internal column by calculating its influence area and determine the total load on each floor part of column

Check if the column is classified as being short if:

Effective height calculation

The equation $Le = \beta Lo$ represents a relationship used in structural engineering to calculate the effective height (Le) of a column based on the unbraced length (Lo) and a coefficient (β) that takes into account the column's end conditions and lateral bracing.

Where:

Le: represents the effective height of the column.

Lo: denotes the unbraced length of the column, which is the distance between points where the column is restrained against lateral movement (braced points).

β: This coefficient, often called the "slenderness ratio factor," accounts for how the column is braced and restrained against lateral movement. It varies based on the type of column end conditions. Our column was classified in the End condition 1 which signifies that the column is fully restrained and by that the value of the factor is 0.75.

Load calculation

The load supported by our column is the total weight it carries from the building's components and occupants. This load includes both permanent (dead load) and temporary (live load) weights. Engineers calculate and design columns to handle these loads safely, considering factors like materials, dimensions, and reinforcement. This ensures the column won't fail or deform under the applied forces, contributing to the overall stability and safety of the structure.

Dead Load (Gk): The permanent weight of the structural elements, finishes, and fixtures that are part of the building. It includes the weight of the column itself and other non-moving components.

Live Load (LL): The variable and transient loads caused by occupants, furniture, equipment, and other temporary loads. The Live load value of our building was 2kN/m2 as stated in the BS code for an apartment building except for the roof which was a without access except for maintenance and by that its live load is 0.75kN/m.

The unfactored and factored loads were computed from the fifth floor to the ground floor and they were used to find the required reinforcements steels.

Reinforcement calculation

Where:

As: This represents the required area of tensile reinforcement, in square millimeters (mm^2)

N: This is the axial 22 load applied to the concrete member, expressed in newtons (N).

fcu: This is the compressive strength of the concrete, typically measured in megapascals (MPa)

Ac: This denotes the cross-sectional area of the concrete member, usually in square millimeters

(mm^2)

fy: This is the yield strength of the reinforcement steel, typically in megapascals (MPa)

The equation calculates the required area of tensile reinforcement necessary to balance the effects of the axial load and the concrete's compressive strength. By providing adequate tensile reinforcement, we ensure that the member can withstand both axial and bending loads while maintaining its structural integrity.

3.4.4. Foundation design

Footing area calculation

Footing area = (serviceability load +10% of serviceability load)/bearing capacity of soil

Footing real pressure calculation

Footing real pressure, also known as actual bearing pressure or applied bearing pressure, refers to the load per unit area that is actually transmitted from the structure's foundation or footing to the underlying soil. It is 2 calculated by dividing the total load carried by the footing by the area of the footing in contact with the soil. This calculation takes into account the actual loads from the structure, including 22 dead loads, live loads, and any additional imposed loads. Ultimate bearing pressure (Pu) calculation

Ultimate bearing pressure (Pu) is the maximum load per unit area that the soil can safely withstand without undergoing excessive settlement or failure.

Reinforcements calculation

The equation is applied to footings in structural engineering [2] to calculate the required area of tensile reinforcement for a reinforced concrete footing subjected to bending moment (M). This [3] equation is used to ensure that the footing can safely resist the bending forces and maintain its structural integrity.

Check for punching shear

Figure 7: Critical section for punching shear (Arya, 2022)

The equation Ʊ = (punching force) / (critical perimeter * d) is used to calculate the punching shear stress in a reinforced concrete footing. This equation assesses the shear stress [31] at the critical perimeter around a column or pedestal to determine if the footing is adequately designed to resist punching shear failure.

Where:

Ʊ: represents the punching shear stress, usually measured in pascals (Pa)

Punching force: is the total vertical force applied to the footing by the column or pedestal, typically in newtons (N).

Punching force = pu*critical area

Critical perimeter: This is the boundary around the column or pedestal where shear failure is most likely to occur. It's defined based on a certain distance from the column, often given as a fraction [2] of the effective depth of the footing.

[31] The critical perimeter is defined by this equation: (3d+column side length) *4

d: This represents the effective depth of the footing, measured in the same units as the critical perimeter.

Shear capacity

The expression represents a formula used to calculate the critical shear stress in a reinforced concrete footing.

The condition $Ʊ_c > Ʊ$ must be respected to assure that punching failure will not occur.

Check for face shear

Figure 8:Face shear critical section (Arya, 2022) Maximum shear stress Ʊmax occurs at face of column. Hence

Check for transverse shear

Figure 9: Critical section for transverse and face shear (Arya, 2022)

$$Ultimate\ shear\ force\ (V) = load\ on\ shaded\ area = earth\ pressure * area$$

Design shear stress

If > no shear reinforcement will be required; if not, provide shear reinforcements.

3.3.5. Stair design

The staircase must be designed in a way that there will be a comfort when one is climbing it. [27] It is necessary to check for the conformability of the staircase. Check if 550-2R+T<700, where R=riser and T = Tread.

Note: T+1=R

>Steps for Design:

Step 1: Calculate the effective length of stairs

Step 2: [2] Calculate the effective depth of the stairs (Check L/d ratio)

Step 3: Calculate loadings on stairs

Step 4: Calculate the Maximum Bending Moment and Shear Force

Step 5: Check for depth against bending moment

Step 6: Calculate the required steel bars (As)

Loads on stair

Self-weight safety factor x thickness of the equivalent horizontal slab x 1m x 1m x unit weight of reinforced concrete.

Finishes safety factor x thickness of finishes.

Live load-safety factor (1.6) x live load of stair > Required reinforcements

3.5. Cost and estimation

In the pursuit of attaining a comprehensive estimation of the overall cost associated with the building project, a systematic approach has been undertaken, characterized by the utilization of the quantity take-off method and the unit cost method which are closely related.

3.5.1. Quantity Take-Off (QTO)

In the Quantity Takeoff method, the building is divided into distinct components like walls, floors, and roofs. Using construction drawings, the quantities of materials needed for each component are determined. These quantities are then multiplied by their respective unit costs, derived from historical data and market rates, to calculate the overall project cost. This method ensures precise cost estimates based on the specific requirements of each building element.

This [2] method is used in our bill of quantity as an input provider; it is used to break down the drawings, the various building elements.

3.5.2. Unit cost (UCM)

[38] The Unit Cost method involves assigning unit costs to various materials and construction activities. These unit costs represent the cost per unit of measurement, such as per square meter or per cubic meter. Unit costs are typically obtained from historical data, market rates, and supplier quotations. The total cost of a particular construction activity or material is calculated by multiplying its unit cost by the quantity required.

3.5.2.1. Unit of measurement

When manufacturers create a product, they choose the most suitable packaging and selling strategy for that specific product. Consequently, the measurement of various materials may vary based on the characteristics and requirements of the product. In other words, different products may be measured and presented differently due to their unique attributes and market considerations. Here down are listed the various measurement ways:

i. Unit count

Items nails, windows and doors [5] are materials counted in units. With items like nails, a unit consists of 500 or a unit can be an individual object, like air conditioners, or windows. This measurement technique is used for doors, windows and the lift in our bill of quantity.

ii. Linear length

Although we can count pipes, electrical wiring, or pieces of steel, suppliers sell them according to length. So, they must be calculated by the linear length.

iii. Surface area

To calculate the amount of material to cover an area, like wall plastering, the space's length and width is multiplied to find the surface area.

This measurement technique is used for flooring and wall plastering in our bill of quantity calculation.

iv. Cubic volume

When filling space, such as with concrete the measurements required are length x width x height. This calculation will result in the cubic volume of the material, allowing you to calculate its cost estimation accurately.

This measurement technique is used for column bases (footings), columns, beams, and slab in our bill of quantity calculation.

v. [12] Physical weight

Materials like sand or backfill come in weight measurements, such as a ton of sand. They are usually purchased in a standard amount and an overestimation is needed to ensure enough quantity is ordered.

3.5.3. Relationship between QTO and UCM

The two methods are closely related because they often work together in the cost estimation process. The quantities determined through the Quantity Takeoff method serve as inputs for 38 the Unit Cost method. By 36 multiplying the quantities by their respective unit costs, the overall cost for each component can be accurately calculated. So, while they are distinct methods, they are often used in conjunction to provide a comprehensive and accurate cost estimate 1 for a construction project.

3.5.4. Bottom-Up Estimating method:

This method involves estimating the cost of individual components and activities, such as excavation, site clearing or site leveling. These individual estimates are then aggregated to determine the overall project cost.

3.5.4.1. Bottom-Up estimating process

The Bottom-Up Estimating method involves a systematic process. It starts 33 by breaking down the project into smaller components or tasks, like excavation work, framing, roofing, etc. Then, costs are estimated individually for each component, factoring in labor, materials, and resources using historical data, quotes, and benchmarks. This detailed analysis ensures accuracy, considering factors like labor rates, material prices, and potential contingencies.

These individual costs are aggregated to determine 33 the total project cost, offering a dependable financial projection. The method is known for its accuracy and transparency due to its consideration of unique component aspects. It's particularly effective for complex projects with diverse elements. Additionally, this method facilitates project control, allowing managers to closely monitor expenses for each component, leading to accurate financial management in response to project changes.

This method is 3 used to provide the cost and estimation of the excavation works, site clearing and site leveling in the bill of quantity.

3.5. Structural design information

All the structural elements of the building are designed according to BS 8810 standard, and softwares like, Prokon 10 for the design of footing and ETABS for the design of column, beam and slab. The following parameters are used 13 in the structural design:

The Floor imposed load for commercial places is 4 KN/m2

Floor Finishing: 1.5KN/m2

Self-weight for concrete: 24KN/m3

Wall self-weight: 19KN/m3

Plaster self-weight: 20KN/m3

Reinforcement:

24 Characteristic strength of main reinforcement (Fy) = 460 N/mm2

Characteristic strength of stirrups (Fyv) = 250 N/mm2

Cost estimation

Estimating is the technique of calculating or computing the various quantities and expected expenditure to be incurred on a particular work or project. The quantity 8 like earth work, foundation concrete, brickwork, can be workout by Long wall-short wall method: in this method, the wall along the length of room is considered to be long wall while the wall perpendicular to long wall is said to be short wall. To get the length of long wall or short wall, calculate first the center line lengths of individual walls. Then the length of long wall, (out to out) may be Calculated after adding half breadth at each end to its center line length. Thus the length of short wall measured into in and may be found by deducting half breadth from its center line length at each end. These lengths are multiplied by breadth and depth to get quantities.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Description of building

This Residential and Commercial Building composed with ground floor plus four stories (G+4) It has 27.5m to 29m, and it covers the total area of 797.5 Square meters. On the ground floor, the building has restaurants areas, kitchen, laundries, store rooms and restrooms. The first floor has multipurpose hall, gym, sauna, bar and restrooms. Second floor has offices, multipurpose hall, sauna, bar and restrooms. Third floor and fourth floor are unique, they bedrooms and apartments and restrooms. In addition, the building has both horizontal access ways such as lobby. For vertical transportations, the building is designed with 3 staircases and two lifts.

Figure 13: Structure Floor plan

4.2. Structure design of the building

4.2.1 Introduction

The primary objective of the structural analysis is to obtain a set of internal forces and moments throughout the structure that are in equilibrium with the design loads for the required loading combinations. The building carries distributed load (dead load and live load) over the spans. From a live load point of view, the structure needs to be analyzed for all placements of the loads. Such placements of the loads are known as load patterns. The design should satisfy the requirement of the building or any part of the structure must withstand the worst combination of these loads. The design load combination is obtained by multiplying the characteristic loads by appropriate partial factors of safety.

Figure 14: Structure perspective

Figure 15: 3D masonry load assign

4.2.2. Slab design

20 Durability and fire resistance

Nominal cover for very moderate conditions of Exposure= 25mm

Nominal cover for 1.5 hours fire resistance= 20mm

since 25>20, provide nominal cover = 25mms

the panel has (4800*4620) mm.

Estimating the modification factor to be of the order of 1.4

Ly=4800m

Lx= 4620m

For our slab; Ly / Lx = 1.03< 2 so we have a two-ways slab.

Depth of slab (clause 3.5.7, BS 8110)

Figure 16: Initial calculation of slab depth

So, dmin=

Take trial bar diameter of 10mm

Total slab thickness(h)= +25+ ,take h=150mm

Figure 17: Input

Figure 18: Bending Moments

Deflection check

Ultimate deflection

fu=l/500 (Allowable deflection)

fu= =9.6mm (Allowable deflection)

3<9.6mm

Figure 19: Rebar area

Figure 20: Bending schedule

4.2.3. Beam design

Figure 21: Bending moment diagram of the frame

Figure 22: Critical bending moment

Max. Negative moment: 133.8623kNm (required steel bars:880 mm2), use 5-D16 bars top

Max. Positive moment: 121.97kNm (required steel bars: 784mm2), use 4-D16 bottom

Max. shear force: 129.4035 KN (require

d steel bars: 723.66mm2/m), use D8@125

Beam Element Details

Level

Element

Unique Name

Section ID

Combo ID

Station Loc

Length (mm)

LLRF

GL

B36

559

BEAM 500*200

DCon2

6070

6220

1

Section Properties

b (mm)

h (mm)

bf (mm)

ds (mm)

dct (mm)

dcb (mm)

200

500

200

0

41

41

Material Properties

Ec (MPa)

fcu (MPa)

Lt.Wt Factor (Unitless)

fy (MPa)

fyv (MPa)

31000

25

1

460

250

Design Code Parameters

γ_C

γ_S

γ_M

1.5

1.15

1.25

Design Moment and Flexural Reinforcement for Moment, M3

Design

-Moment

kN-m

Design

+Moment

kN-m

-Moment

Rebar

mm²

+Moment

Rebar

mm²

Minimum

Rebar

mm²

Required

Rebar

mm^2

Top (+2 Axis)

-133.8623

880

148

880

Bottom (-2 Axis)

121.97

784

0

784

Shear Force and Reinforcement for Shear, V2

Shear V

kN

Shear Vc / ɣM

kN

Shear Vs / ɣM

kN

Rebar Asv /S

mm^2/m

129.4035

57.195

72.2085

723.66

4.2.4. Column design

Figure 23: Assigned masonry loads on beams (elevation 5)

Figure 24: Axial force

Figure 25: Critical column

Column 26 Element Details

Level

Element

Unique Name

Section ID

Combo ID

Station Loc

Length (mm)

LLRF

Story1

C10

330

COL 400*300

DCon2

0

3100

0.436

23 Section Properties

b (mm)

h (mm)

dc (mm)

Cover (Torsion) (mm)

300

400

45

15

Material Properties

Ec (MPa)

fcu (MPa)

Lt.Wt Factor (Unitless)

fy (MPa)

fyv (MPa)

31000

25

1

460

250

Design Code Parameters

Ec (MPa)

fcu (MPa)

Lt.Wt Factor (Unitless)

31000

25

1

30 Axial Force and Biaxial Moment Design For N , M2 , M3

Design N

kN

Design M2

kN-m

Design M3

kN-m

Minimum M2

kN-m

Minimum M3

kN-m

Rebar Area

mm^2

Rebar %

%

2781.0455

-41.1202

60.0209

45.0157

60.0209

3298

4.94

Axial Force and Biaxial Moment Factors

Mi Moment

kN-m

Madd Moment

kN-m

β Factor

Unitless

Length

mm

Major Bend(M3)

4.0533

25.3588

1

2600

Minor Bend(M2)

-2.9234

-33.8118

1

2600

Shear Design for V2, V3

Shear V

kN

Shear Vc / ɣM

kN

Shear Vs / ɣM

kN

Rebar Asv /s

mm²/m

Major, V2

2.8455

389.804

42.6002

552

Minor, V3

4.8695

408.003

40.8003

736

Required steel reinforcements: 12-D20

For Shear: D8@175(hoops or stirrups)

4.2.5. Stair design

A stair is a set of steps leading from one floor to another, typically inside the building. [16] The room or enclosure of the building in which the stair is located is known as staircase. The opening or space occupied by the stair is known as a stairway

Note: for initial design: we asume R=150~175mm and T=200~250mm, where R: riser and T:tread.

Let R= 175 mm

No of Riser= 3.5m /0.175m = 20

No of risers per flight= 20/2= 10

No of Tread per flight= 10-1= 9

Then, let tread (T) =250 mm

Total going (G) = 9 (T) * 0.25 (tread length) = 2.25m

Check conformability: 2R+T= 2*175+250= 600 …… OK

Step 1: [27] Effective length of the stair: 1+2.25+1= 4.25m

Step 2: For stair that is fixed at both end: then L/d=30

d= L/30 = 150 mm, assume: 150 mm, using bar size of 12 mm

Waist thickness (D) = d+12/2+20mm (cover): 150+12/2+15= 176mm,

Use, D: 180mm (depth of waist slab or landing slab depth)

Effective depth (d): 180-12/2-20= 154mm.

Step 3: loading calculation

Load on landing: We consider 1-m width of slab

a) Live load: 3KN/m

b) Floor finish: 0.8KN/m

c) Self-weight: 24 (concrete unit weight) x 0.180 x 1 = 4.32KN/m

Factored load: 1.4 DL + 1.6 LL = 1.4 (4.32+0.8) + 1.6 (3) = 11.96 KN/m

Load on stairs:

a) Live load: 3KN/m

b) Floor finish: 0.8KN/m

c) Self-weight of waist slab per Tread: $\gamma \times D \times (\sqrt{T2+R2}) \times 1/T$, γ= 24 Unit weight of concrete

=24 ×0.18× (√0.252+0.1752) ×1/0.25= 5.27 KN/m

d) Self-weight of steps per Tread: $\gamma \times (1/2 \times R \times T) \times 1/T$= (24×1/2×0.175×0.25) ×1/0.25=2.1 kN/m

Factored load: 1.4(2.1+0.8+5.27) + 1.6(3) = 16.24KN/m

2 Step 4: Calculate the Maximum Bending Moment and Shear Force

Vmax= wl/2 = (11.7 x 1 + 15.361 x 2.5 + 11.7 x 1)/2 = 30.23 KN

P= 11.96 P = 16.24Kn/m P= 11.96

30.23KN 1 m 2.25 1 m

Mmax= 30.23 x 2.125- 11.96 x 1.625 – 18.27 x 1.125 = 24.25KNm

Step 5: Check for depth against bending moment

Mu= 0.156*fcu*bd2, from this equation, we can find effective depth “d”

drequired= √(24.25 ×106)/0.156×25×1000=78.8 mm<154 mm

The assumed d= 154mm is adequate!

Step 6: calculated the required steel bars

K= M____ = 24.25 × 106__ = 0.04

Fcu bd2 25×1000×1542

z=154[0.5+√0.25−0.04/9] = 146.82 mm > 146.3 mm = 0.95d

As=M/0.87 Fy.z = (25.3 ×106) / 0.87×460×146 = 438 mm2/m, as, required

As, min= (0.13 ×1000×180)/100=234 mm2/m Less than as, required …OK!

Provide Y12@250 (As provided = 452 mm2/m)

4.2.6. Elevator wall / Shear wall design

Figure 26: The 3D of lift or elevator in Etabs

Table 1: Pier Details

Story ID

Pier ID

Centroid X (mm)

Centroid Y (mm)

Length (mm)

Thickness (mm)

LLRF

G+2

P2

15700

2310.5

7200

200

0.639

Table 2: Material Properties

Ec (MPa)

fcu [26] (MPa)

Lt.Wt Factor (Unitless)

fy (MPa)

fys (MPa)

31000

25

1

460

460

Table 3: Design Code Parameters

γC

γS

γM

IPMAX

IPMIN

PMAX

1.5

1.15

1.25

0.04

0.0025

0.8

Table 4: Pier Leg Location, Length and Thickness

Station

Location

ID

Left X1

Mm

Left Y1

mm

Right X2

Mm

Right Y2

mm

Length

Mm

Thickness

mm

Top

Leg 1

14700

3700

16700

3700

2000

200

Top

Leg 2

16700

1300

16700

3700

2400

200

Top

Leg 3

14700

1300

16700

1300

2000

200

Top

Leg 4

14700

1300

14700

3700

2400

200

Bottom

Leg 1

16300

3700

16700

3700

400

200

Bottom

Leg 2

16700

1300

16700

3700

2400

200

Bottom

Leg 3

14700

1300

16700

1300

2000

200

Bottom

Leg 4

14700

1300

14700

3700

2400

200

Bottom

Leg 5

14700

3700

15100

3700

400

200

Table 5: Flexural Design for N, M2 and M3

Station

Location

Required

Rebar Area (mm²)

Required

Reinf Ratio

Current

Reinf Ratio

Flexural

Combo

N

kN

M2

kN-m

M3

kN-m

Pier Ag

mm²

Top

4400

0.0025

0.0113

1.4DL+1.6LL

2069.4432

-526.3822

-244.2678

1760000

Bottom

3800

0.0025

0.0112

1.4DL+1.6LL

2268.1845

-585.5605

-0.6422

1520000

Area required for the shear wall or elevator is 4400 mm2

The reinforcement provided is Y12@200mm as show below on the figure of details

Figure 27: Lift or elevator

4.2.7. Footings design

6 A building is generally composed of a superstructure above the ground and a structure that forms the foundations below the ground. The foundations transfer and spread the loads from a structure's columns, roof and walls, into the ground.

Figure 28: critical column base

Figure 29: Input

Figure 30: Design

Figure 31: Bending schedule

4.3. Analytical investigation

4.3.1. Slab design

A. Load calculation

Self-weight=24*0.15= 3.6 kN/m2

Design load =1.4(3.6+3.7+1.5) +1.6(2) =17.12kN/m2

B. Bending moment calculations

Generally, M=αnLx

Mx- = 0.042*17.12*4.622= 15.34kNm/m

Mx+= 0.032*17.12*4.622= 11.69kNm/m

My-= 0.032*17.12*4.622= 11.69kNm/m

My+= 0.024*17.62*4.622= 9.02kNm/m

M-max= 15.34kNm/m

M+max= 11.69kNm/m

C. Area and spacing at the middle of span (11.609kNm/m)

Effective depth, d= h-cover- φ/2= 150-25-10/5=120mm

K= = = 0.03 k'= 0.156

No compression steel required

Z=d*[0.5+] = 120*[0.5+] = 115.86mm 0.95d=114mm

Keep Z= 114mm

As required= = =256.23mm2

As min = 0.13%bh= 0.13/100*1000*150=195mm2

Since As required As min, As= 195mm2

Spacing = = = 402.6mm   300mm

As provided = = 261.76mm2

Provide T10 @ 200c/c

A. Area and spacing at the middle of span (15.34kNm /m)

Effective depth, d= h-cover- φ/2= 150-25-10/5=120mm

K= = = 0.041 k'= 0.156

No compression steel required

Z= d*[0.5+] = 120*[0.5+] = 1174.45mm 0.95d=114mm

Keep Z= 114mm

As required= = =336.23mm2

As min = 0.13%bh= 0.13/100*1000*150=195mm2

Since As required As min, As= 195mm2

Spacing = = = 402.6mm   200mm

As provided = = 261.76mm2

Provide T10 @ 200c/c

4.3.2. Beam design

 Design load on slab= 8.8+3

 Beam size= [500*200]mm

Beam on typical slab

Loads

Distribution load from slab to beam

=59.36kN/m

24 Self-weight of beam = 24*(0.5-0.15) *0.2*1.4=2.352kN/m

Self-weight of wall= 18*0.2*(3.1-0.5) *1.4=13.104kN/m

Design load on beam = 59.36+2.352+13.104=74.816kN/m

Bending moment

M-max= -0.11FL=-0.11*411.58*4.8=217.31kNm

M+max= 0.09FL=0.09*411.58*4.8=177.8kNm

F=74.816*4.8=411.58kN

Area and number of bars for M+Max=217.3kNm.

At the middle of span, the beam is designed as T-beam

Effective width of flanged section=200+)=870mm

Ultimate 2 moment of resistance of flanged section

Mf=0.45*25*870*150(457-)=560820000N-mm

Mf=560.82kN-m

d=457mm assuming that φmain: 20mm, φstirrup: 8mm and cover = 25mm

=0.156

No compression reinforcement required

Keep

Provide, 5T16

Area and number of bars for M-Max=177.8kNm.

=0.156

4.3.3. Column design

Load from the slab

Dead load=5.7*4.62*4.8=126.4kN

Live load=3*4.62*4.8=66.528kN

Load from beam=15.4456*(4.8+4.62) =145.59kN

Self-load on column=*24*0.5*0.5*4=24kN

Total Dead load= 362.52*4.8=1740.11kN

Live load=66.528kN*4.8=332.64kN

Total design load=1.4(1740.11) +1.6(332.64) =2968.378kN

Provide T8@175

4.3.4. Footing design

Serviceability load=1724.17+589.64=2313.81kN

BENDING REINFORCEMENT

Self-weight of footing

Assume the overall depth of footing (h) = 600 mm

Self-weight of footing = area × h × density of concrete = 9 × 0.6 × 24 = 129.6kN

Maximum design moment occurs at face of column (M)= 165.8kN

Ultimate moment Effective depth Base to be cast against blinding, hence cover (c) to reinforcement = 50 mm. Assume 25 mm diameter (Φ) bars will be needed as bending reinforcement in both directions

Average effective depth of reinforcement, d, is

d = h − c − Φ = 600 − 50 − 20 = 530 mm

Ultimate moment

Mu = 0.156fcubd2

Mu = 0.156 × 40 × 103 × 5302 = 1685.4 × 106 N-mm = 1685,4 kN-m

Since Mu > M no compression reinforcement is required.

Main steel

CHAPTER 5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The general objective of this project was to produce an architectural and [13] structural design of a G+4 Residential and Commercial Building using ArchiCAD 19, architectural design was done and architectural drawings were prepared. The structural design was done using ETABS and Prokon structural analysis professional 2018 and structural drawings were prepared. [5] The bill of quantities of the building was prepared. The objective of this research project was successfully achieved and [37] all the research questions of this study were answered successfully.

5.2. Recommendations

Based on different challenges that I ran into during this research project, I recommend to ULK Polytechnic Institute the following:

- To provide to civil engineering students enough knowledge and skills on [1] the use of computer software in civil engineering projects.
- To provide easily the equipment required to perform different laboratory and field tests that are needed to perform different types of research projects.
- For the students who would continue this project, would design ramp.
- For the students who would continue this project, would [12] estimate the cost of elevator/rift (shear wall).
- And also, the students would design and do electrical and plumbing installations.

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APPENDICES

Appendix A: Bill of quantity

S/N

DESCRIPTION

UNITS

QUANTITY

RATE (Rwf)

TOTAL AMOUNT(Rwf)

A.GROUND LEVEL

PRELIMINARY WORKS

Site cleaning

Ls

1

1,000,000

1,000,000

site installation

Ls

1

1,000,000

1,000,000

S/Total 1

2,000,000

FOUNDATION

Excavation for foundation

m3

324

1,500

486,000

Base concrete

m3

719.28

82,000

58,980,960

Concrete Bed

m3

340

400,000

136,000,000

Stone foundation with mortar

m3

321.6

50,000

16,080,000

S/Total 2

211,546,960

Elevations

Walls of bricks with cement mortar

m3

246.06

59,000

14,517,540

Columns in concrete

m3

48

380,000

18,240,000

slabs, stairs and ramp

m3

285

350,000

99,750,000

Beams and tie beams

m3

140.96

210,000

29,601,600

S/Total 3

162,109,140

Doors and windows

Doors of 200cmx300cm

Items

46

100,000

4,600,000

Doors of 80cmx200cm

Items

8

80,000

640,000

Windows 0f 50cmx75cm

Items

2

30,000

60,000

S/TOTAL 4

5,300,000

FINISHES

Plastering int & ext.

m2

468

6,480

3,032,640

Wall tiles

m2

36

36,000

1,296,000

Pavement with tiles

m2

940.5

36,000

33,858,000

Latex paints

m2

468

5,760

2,695,680

Email paints

m2

468

7,200

3,369,600

S/TOTAL 5

44,251,920

PLUMBING AND DRAINADE INSTLATION

Water reticulation to the existing network

Ls

1

500,000

500,000

Supply and installation of WC of good quality complete with all accessories and all requirements

Items

16

250,000

4,000,000

Supply and installation of ceramic wash hands basin complete with accessories and all requirements.

Items

4

80,000

320,000

Supply and installation of urinal complete with accessories and all requirements.

Items

16

30,000

480,000

S/TOTAL 6

5,300,000

ELECTRICAL INSTALLATION WORKS

Provide for general attendance on specialist installing mains connection. and main switchboards, distribution boards and circuits, power and lighting installations and lightning conductors.

LS

1

200,000

200,000

Extinctic of 9kgs

Items

16

81,000

1,296,000

Main switchboards, distribution boards (cabin)

Items

1

180,000

180,000

Single switch

Items

35

1800

63,000

Double switch

Items

8

3150

25,200

Power distribution boards

Items

5

1125

5,625

S/TOTAL 7

1,769,825

TOTAL OF GROUND FLOOR

432,277,845

B.FIRST FLOOR

Elevations

Walls of bricks with cement mortar

m3

332.5

36,000

11,970,000

Base concrete

m3

48

120,000

5,760,000

Columns in concrete

m3

48

249,000

11,952,000

slabs and stairs, ramp reinforced concrete

m3

295

210,000

61,950,000

Beams and tie beams

m3

140.96

210,000

29,601,600

S/Total 1

121,233,600

Doors and windows

Doors of 200cmx300cm

Items

46

100,000

4,600,000

Doors of 80cmx200cm

Items

8

80,000

640,000

Windows 0f 50cmx75cm

Items

2

30,000

60,000

S/TOTAL 2

5,300,000

FINISHES

Plastering int & ext.

m2

468

6,480

3,032,640

Wall tiles

m2

36

36,000

1,296,000

Pavement with tiles

m2

940.5

36,000

33,858,000

Latex paints

m2

468

5,760

2,695,680

Email paints

m2

468

7,200

3,369,600

S/TOTAL 3

44,251,920

PLUMBING AND DRAINADE INSTLATION

Piping works to include water supply and drainage

Ls

1

1,500,000

1,500,000

Drainage works to include the provision of drainage facility such as manholes, septic tanks, soak way pits

Ls

1

3,500,000

3,500,000

Water reticulation to the existing network

Ls

1

500,000

500,000

Supply and installation of WC of good quality complete with all accessories and all requirements

Items

16

250,000

4,000,000

Supply and installation of ceramic wash hands basin complete with accessories and all requirements.

Items

4

80,000

320,000

Supply and installation of urinal complete with accessories and all requirements.

Items

16

30,000

480,000

S/TOTAL 4

10,300,000

ELECTRICAL INSTALLATION WORKS

Provide for general attendance on specialist installing mains connection and main switchboards, distribution boards and circuits, power and lighting installations and lightning conductors.

LS

10

81,000

810,000

Extinctic of 9kgs

Items

16

81,000

1,296,000

Main switchboards, distribution boards (cabin)

Items

1

180,000

180,000

Single switch

Items

29

1800

52,200

Double switch

Items

8

3150

25,200

Power distribution boards

Items

5

1125

5,625

S/TOTAL 5

2,369,025

TOTAL OF FIRST FLOW

183,454,545

C. SECOND FLOOR

Elevations

Walls of bricks with cement mortar

m3

332.5

36,000

11,970,000

Base concrete

m3

48

120,000

5,760,000

Columns in concrete

m3

48

249,000

11,952,000

slab, stairs and ramp

m3

295

210,000

61,950,000

Beams and tie beams

m3

140.96

210,000

29,601,600

S/Total 1

121,233,600

Doors and windows

Doors of 200cmx300cm

Items

46

100,000

4,600,000

Doors of 80cmx200cm

Items

8

80,000

640,000

Windows 0f 50cmx75cm

Items

2

30,000

60,000

S/TOTAL 2

5,300,000

FINISHES

Plastering int & ext.

m2

468

6,480

3,032,640

Wall tiles

m2

36

36,000

1,296,000

Pavement with tiles

m2

940.5

36,000

33,858,000

Latex paints

m2

468

5,760

2,695,680

Email paints

m2

468

7,200

3,369,600

S/TOTAL 3

44,251,920

PLUMBING AND DRAINADE INSTLATION

Piping works to include water supply and drainage

Ls

1

1,500,000

1,500,000

Drainage works to include the provision of drainage facility such as manholes, septic tanks, soak way pits

Ls

1

3,500,000

3,500,000

Water reticulation to the existing network

Ls

1

500,000

500,000

Supply and installation of WC of good quality complete with all accessories and all requirements

Items

16

250,000

4,000,000

Supply and installation of ceramic wash hands basin complete with accessories and all requirements.

Items

4

80,000

320,000

Supply and installation of urinal complete with accessories and all requirements.

Items

16

30,000

480,000

S/TOTAL 4

10,300,000

5

ELECTRICAL INSTALLATION WORKS

Provide for general attendance on specialist installing mains connection and main switchboards, distribution boards and circuits, power and lighting installations and lightning conductors.

LS

10

81,000

810,000

Extencticher of 9kgs

Items

16

81,000

1,296,000

Main switchboards, distribution boards (cabin)

Items

1

180,000

180,000

Single switch

Items

29

1800

52,200

Double switch

Items

8

3150

25,200

Power distribution boards

Items

5

1125

5,625

S

S/TOTAL 5

2,369,025

TOTAL OF SECOND FLOOR

183,454,545

D. THIRD FLOOR

Elevations

Walls of bricks with cement mortar

m3

332.5

36,000

11,970,000

Base concrete

m3

48

120,000

5,760,000

Columns in concrete

m3

48

249,000

11,952,000

slabs, stairs and ramp

m3

295

210,000

61,950,000

Beams and tie beams

m3

140.96

210,000

29,601,600

S/Total 1

121,233,600

Doors and windows

Doors of 200cmx300cm

Items

46

100,000

4,600,000

Doors of 80cmx200cm

Items

8

80,000

640,000

Windows 0f 50cmx75cm

Items

2

30,000

60,000

S/TOTAL 2

5,300,000

FINISHES

Plastering int & ext.

m2

468

6,480

3,032,640

Wall tiles

m2

36

36,000

1,296,000

Pavement with tiles

m2

940.5

36,000

33,858,000

Latex paints

m2

468

5,760

2,695,680

Email paints

m2

468

7,200

3,369,600

S/TOTAL 3

44,251,920

4

PLUMBING AND DRAINADE INSTLATION

Piping works to include water supply and drainage

Ls

1

1,500,000

1,500,000

Drainage works to include the provision of drainage facility such as manholes, septic tanks, soak way pits

Ls

1

3,500,000

3,500,000

Water reticulation to the existing network

Ls

1

500,000

500,000

Supply and installation of WC of good quality complete with all accessories and all requirements

Items

16

250,000

4,000,000

Supply and installation of ceramic wash hands basin complete with accessories and all requirements.

Items

4

80,000

320,000

Supply and installation of urinal complete with accessories and all requirements.

Items

16

30,000

480,000

S/TOTAL 4

10,300,000

5

ELECTRICAL INSTALLATION WORKS

Provide for general attendance on specialist installing mains connection and main switchboards, distribution boards and circuits, power and lighting installations and lightning conductors.

LS

10

81,000

810,000

Extencticher of 9kgs

Items

16

81,000

1,296,000

Main switchboards, distribution boards (cabin)

Items

1

180,000

180,000

Single switch

Items

29

1800

52,200

Double switch

Items

8

3150

25,200

Power distribution boards

Items

5

1125

5,625

S/TOTAL 5

2,369,025

TOTAL OF THIRD FLOOR

183,454,545

E. FOUTH FLOOR

Elevations

Walls of bricks with cement mortar

m3

332.5

36,000

11,970,000

Base concrete

m3

48

120,000

5,760,000

Columns in concrete

m3

48

249,000

11,952,000

slabs, stairs and ramp

m3

295

210,000

61,950,000

Beams and tie beams

m3

140.96

210,000

29,601,600

S/Total 1

121,233,600

Doors and windows

Doors of 200cmx300cm

Items

46

100,000

4,600,000

Doors of 80cmx200cm

Items

8

80,000

640,000

Windows 0f 50cmx75cm

Items

2

30,000

60,000

S/TOTAL 2

5,300,000

FINISHES

Plastering int & ext.

m2

468

5,400

2,527,200

Wall tiles

m2

36

30,000

1,080,000

Pavement with tiles

m2

940.5

30,000

28,215,000

Latex paints

m2

468

4,800

2,246,400

Email paints

m2

468

6,000

2,808,000

S/TOTAL 3

36,876,600

PLUMBING AND DRAINADE INSTLATION

Piping works to include water supply and drainage

Ls

1

1,500,000

1,500,000

Drainage works to include the provision of drainage facility such as manholes, septic tanks, soak way pits

Ls

1

3,500,000

3,500,000

Water reticulation to the existing network

Ls

1

500,000

500,000

Supply and installation of WC of good quality complete with all accessories and all requirements

Items

16

250,000

4,000,000

Supply and installation of ceramic wash hands basin complete with accessories and all requirements.

Items

4

80,000

320,000

Supply and installation of urinal complete with accessories and all requirements.

Items

16

30,000

480,000

S/TOTAL 4

10,300,000

ELECTRICAL INSTALLATION WORKS

Provide for general attendance on specialist installing mains connection and main switchboards, distribution boards and circuits, power and lighting installations and lightning conductors.

LS

16

81,000

1,296,000

Extencticher of 9kgs

Items

16

81,000

1,296,000

Main switchboards, distribution boards (cabin)

Items

1

180,000

180,000

Single switch

Items

29

1800

52,200

Double switch

Items

8

3150

25,200

Power distribution boards

Items

5

1125

5,625

S/TOTAL 5

2,855,025

TOTAL OF FOURTH FLOOR

176,565,225

OVERALL TOTAL

1,159,206,705

Appendix B: 9 Residential and Commercial Building Front view

Appendix C: Residential and Commercial Building Back view

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