DECLARATION OF ORIGINALITY

I do here by declare that the wok presented in this dissertation is my own contribution to the best of my knowledge. The same work has never been or institution submitted to any other university I therefore declare that this work is my own for the partial fulfilment of the award of advanced diploma with honors in civil Engineering at ULK

Signature of the candidate……………….

Date of sub mission………/…………/……………

APPROVAL

This is to certify that this dissertation work entitled "structural design of green commercial building, case study: Gasabodistrict ,Gisozi sector"is an original study conducted by **BIKORIMANA Josue** and has been submitted with the approval of Supervisor under His guidaance.

Thesupervisorname:**Eng. MUNYANEZA jean pierre**

Signature of supervisor:…………………………

Submission date.…………/………./…………

DEDICATION

This dissertation is dedicated to

My Almighty God, my beloved parents,

Brothers, sisters, relatives,

friends and colleagues for their love

and support me during my educational period.

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My deep gratitude goes to my supervisor, **Eng.MUNYANEZA JEAN pierre…..**for his tireless supervision and guidance in the writing of this dissertation. .My appreciation goes to ULK and its various departments especially Civil Engineering department and lectures for the knowledge they gave me during my undergraduate study.

I am very thankful to all members of my family especially my lovely parents and my be loved 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 every one 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.

MAY GOD BLESS YOU ALL!

ABSTRACT

Globally, Greenbuilding project have surfaced in the last few decade as a symbol of the world' spre occupation forecological affairs. However, just as solutions to climate change have emerged, so have those who capitalize on the need for green alternatives. (Jacquez, 2023)

In2017, Rwanda Housing Authority incollaboration with the Global Green Growth Institute, the Building Construction Authority (BCA) of Singapore, Rwanda Green Building Organization (RwGBO), and other stakeholders, initiated the development of the Green Building Minimum Compliance System (GBMCS). (Arrabothu.,2023)

Thus, this study entitled"structure design of green commercial building"

Is aimed to design agreen commercial building at GISOZIsector of GASABO district so that to reduce the over all impact of the building environment on human health and the natural environment.

Structural design concepts are carried out by mean of ArchiCADsoftware and the analysis focused on all structural members such as foundation, beam, slab, column, and stair According to the applied loads, the critical members was designed and required steel reinforcements were provided.

TABLE OF CONTENTS

LISTOFFIGURES

LISTOFTABLES

LISTOFABBREVIATIONS

As	: Cross sectional area of tensile reinforcement
Asv	: Area of steel in links
B	: Effective breadth
Bf	: Width of flange in a beam
Bw	: Width of web in a beam

D.L : Dead load

Df : Depth of foundation

S.F : Safety factor

Fck : Compressive strength

Fcu : Characteristic yield strength of concrete

Fy : Characteristic yield strength of steel

G : Going Hf: depth of the slab

Ho : Effective depth of the cross section

L.L : Live load

Lx **:** The length of the shorter side

Ly : The length of the longer side

MPa : Mega Pascal

M+X : design moment from the bottom at the shorter side

M+Y : Design moment from the bottom at the longer side

M-X : design moment from the top at the shorter side

M-Y : Design moment from the top at the longer side

P : Dotal distributed load

R : Rise

Rb : Design concrete compression strength

Rs : Design steel tensile strength

V : Shear force

CHAPTER ONE : GENERALINTRODUCTOIN

1.0 Introduction

structural and architectural The goal of creating green commercial buildings is to create eco-friendly structures that are affordable, easy to maintain, and made of natural and renewable resources. Minimizing waste, pollution, and environmental damage.

1.1Background

Green building, sometimes referred to as eco-friendly building, is the use of resources and techniques in the construction of a building in an environmentally and resource-conscious manner.

Approximately 40% of all CO2 emissions are attributable to the construction sector. Of these, half are attributable to building operations and the other half are attributable to the production of construction materials, or "embodied emissions."

Even though developing nations like Rwanda bear some of the blame for climate change, these economies are most affected by its effects. Because of the devastating floods and landslides that have occurred during this year, there is a significant climate risk for nations like Rwanda that could halt the growth momentum. Meanwhile, nations like Rwanda are well-positioned to experience population growth, urbanization, and rising incomes, which will increase demand for better homes, workplaces, hotels, hospitals, and retail establishments. The need for space is a source of carbon emissions, but there is also a chance to make sure that more sustainable building construction methods are used.(Arrabothu, 2023)

In the context of Rwanda, a "green building" is defined as one that maximizes the use of sustainably produced and locally produced building materials, protects the environment, promotes indoor environmental quality, encourages water efficiency, uses passive design principles, and is resilient to the effects of extreme weather events.(Arrabothu, 2023)

This project shows how commercial building should be designed with natural materials, uses little energy and renewable to ensure the users comfortability and environment as well by promotes indoor environmental quality, maximizes the use of locally produce land sustainable building materials.

1.2.Problem statement

According to NISR(2023)report Rwandans we are14million and have alarge housing deficit which is growing every year and is more increasingly pre valentin urban area especially in cities. (Bower, 2020)

According to the ministry of environmental which the green buildings and roofing construction to maintain our climate condition with naturally systems, the current annual housing authority is estimated on the population growth and urban migration currently takingplace (Bower, 2020)

By promoting energy efficient design green building help to conservere sources and reduce operational costs. They also provide healthier indoor environments with improved ventilation, naturallight, andtheuseofnon-toxic building materials as it contains some pollutants originating from rain. Also in this district there are different industries, increasing in vehicle, burning of some used plastic materials that can produce some of green house gasses so there ally solution was found to be designing of the building which has a roof that can enable the plants on it and that convert impervious roof tops into pervious surfaces to absorb water and release it slowly over aperiod oftime.(Waterfurnaceinternational, 2011)

The rate of construction of buildings in green commercial building is high to accommodate the rising number of people looking for settlement the major concern is that almost none of the building adopts the green sustainable design or technologies available in the market during their construction or occupational phases.(Waterfurnace, 2011)

Thus, there will be an increase in the consumption and demand building materials, energy, water, and improve indoor environmental health which in the long run will not be suitable. This research seeks to assess the level of sustainable building designs and explorestechnologies that can be incorporated into building design to make them sustainable (Waterfunance, 2011)

1.3.Scope and limitation of thestudy

The scope of this study is limited to determine the architectural and structural design of G+1 green commercial building for the future environ mentally.

1.4.Objective of theStudy

The overall objective of this study is to establish the level of sustainable buildings in green commercial building and come up with strategies or green technologies that can be in corporated into building designs to reduce their ecological foot prints and investigate the type of environ mentally sustainable green commercial building. (McGraw-Hillconstruction, 2013)

1.5.Specific Objectives

i. To make architectural design of G+1green commercial building.

ii. To carry out the structural design of different reinforced concrete elements.

iii. To make bill of quantities of designed structure.

1.5.1.Personal significance

On the personal interest this study is mandatory work done as the partial ful fillment of requirements for the award of advanced diploma A1 in civil engineering thus it will also help the researchers to improve the knowledge on green commercial building and it help the researchers togain very important information in the conducting the field research.

1.5.2.Scientific and academic Interest

To institute polytechnic of ULK as scientific interest after complication of the report it will be collected and submitted to the library of ULK as the project will cover to many different subjects rerated to engineering courses this will be use directing for other future generations as reference and source of information.

1.5.3.Significance of the Study to Society

The most social economic interest is to get good place for future building engineers firms will be fit from the findings that will ensure which are environmentally sustainable green buildings.

1.6.The Research Question

1.How structure designed will look like?

2.Howstructure element to be used will be made?

3.How much the project will cost?

1.7.Research Hypothesis

There is no green commercial building in Gisozi sector that can be used in commercial activities.

The reason why to propose that structure is to increase infrastructure according to the increasing of population in Rwanda this infrastructure help to minimize the time peoples waste when they went to the far away markets.

And it is very important to construct that green commercial building because the peoples who will use that building they will get fresh air from environment will plant there in other purpose of constructing commercial green building is to minimize the destruction of environment in order to promote good health.

1.8Methodology

The method used in this study to achieve the results is based on software operating like ArchCAD 24, PROTA for the structural design for the analysis of reactions and moment to achieve the quantities, Gis for locating the working space, Then Microsoft office word for reporting thesis and also reading books as the reference for literature review. To achieve our objectives a combinatipon of well –thought-out methods and processes was employed, contributing to the comprehensive completion of our work we were guided by the british standard code, this established set of regurations and practices ensured that our structural considerations aligned with internationally recognized standards, enhancing the safety and durability of the proposed building,we ihave manually designed the structural components, ensuring that every element was optimized for functionality and strength. Gathering data from city administration, refers books using internet connections and asking peoples which are related to the project to collect and give credits for regibility strengthening them for the building activities is the goal at the end.

CHAPTER TWO :LITERATUREREVIEW

2.0 INTRODUCTION

A commercial building also called market is abuilding containing more than one room. The word (MARKET) is a place where people meet to ex change goods and service.

Structural design of green commercial building Earlier research has addressed incur poration of green building tech nologies into commercial building construction from multiple point of views several authors have committed thefinancial, social and environmental benefits in termo effect green design and energy efficiency of green house "some authors have addressed the cost factors including the decision adapt

energy efficient design as well as the overall cost of building green most research has been done by independent institution and organization specialized in the field of construction and real entire sector (McGraw-Hillconstruction, 2013)

Many definitions of what green commercial building is or does exist the ideal [green] project preserve sand restores habitat that is vital for sustaining life and becomes an producer and exporter of resources, materials, energy and water rather than being net consumer. A green building is one whose construction and life time of operation as sure the healthiest possible environment while representing the most efficient and least dis ruptive use of land, water, energy resources (Governors greengovernmentcouncil, 2013).

Advances in tech niques and materials have made it possible to do what was un thinkable only a few years ago; design buildings that enhance the environment in stead of ex ploiting it (waterfurnaceinternational, 2011).

An inte grated design approach that addresses the potential of site, waterconservation. Energy efficiency and renewable energy aswell as selection of building materials and in door environmental quality isused todefine agreen building (waterfurnanceinternational, 2011)

In 2008, McGrawhillconstruction(MHC) surveyed firm around the world to gain an insight into global green building trends. The study, the global green building trends Smart market report, was one of the first ever studies focusing on green buildings and aiming to discern differences driving the green building marketplace(McGraw-Hillconstruction, 2013)

Sustainability is not just about green building design and construction; cities around the world are in the early stages of mobilizing against thee effects of global warming through green infrastructure solution.

Whether at one of green house gas emission is released in North America, Africa raise its effect on planet is the same.

Reducing those emissions might be achieved a lot economically with water purification project in Africa than with a roof full of photo voltaic paninthe UnitedStates. That is the principle behind global carbon market (McGraw-Hillconstruction, 2013)

2.1Carbon building activity and to male African are slowly

Re search in Rwanda forgreen building initiatives is timely undertaken that is why leader in innovation and knowledge discrimination Ihave decided one of the most logical places to my country as Rwanda green building organization (RWGBO).

2.2.Green building technologies and fundamentals of green buildings.

The five major elements of green building designed discussed in this study are: water conservation and efficiency, energy efficiency, environmental improvement quality and conservation of materials and resources (Rahall, 2009)

.blending the right mix of green technologies that cost less with green technologies that cost the same or slightly more, it is possible to have green building that cost the same as convention alone. The key to cost effective green building and site design rise with in the inter relationships and associated cost performance trade-offs that exist between different building systems(GovernsGreenGovernmentCouncil, 2013).

A good example is to inter relationships between the building site, site features, the path and location and orientation of building and element such as window and external shading device have significant impact on the quality and effective ness of natural day lighting. These elements also affect direct solar roads and over all energy performance (forthelifeofbuilding, 2013)

2.3Sustainable site design

This involves engaging in design and construction process that minimizes overall site distur bance and which values, preserve sand restores of re generate valuable habitat, greenspace and associate deco-systems that are vitalto sustaining life. The lay out and design of building and site ground has an impact on energy and water consumption. A green planned site planned site will preserve much of the existing natural vegetation, increase energy efficiency and reduce amount of storm water leaving building(RebeccaBrownstone, 2004)

Smart lighting and power saving electrons are simple way to save energy to a residential building. These energy were designed to shout down when ere in smart light phase natural light in the building and dimel electric light natural light smart are often equipment with motion services so that when there is no sustainable room the light automatically shut off (RebeccaBrownstone, 2004)

Use energy star contused energy efficiency appliance an y home equipment, lighting and HVAC(Heating Ventilationand AirCondition) system by optimizing the use of natural ventilation and where practical use cooling energy efficiency can be greatly increased home owners should also avoid the use of halogen and refrigeration, cooling, and fire suppression system (GOVEMOS GREEN GOVERNOMENTAL COUNCIL, 2013).

The benefit to smart lighting and power saving electronics is the reduction in the over all energy consumption of the building thus tradition in energy costs.

The greatest challenges to all energy production is its impact on the environment. Solar power is the one of the environmental friend liest ways of producing electricity or heating energy. In grid connected system, solar power has no effect on the environmental, because the system does not include batteries and would need to be replaced (RebeccaBrownstone, 2004)

.Hot water is the largest water component of residential energy cost after heating and cooling (Cassedy, 2004)

.A well designed water heating system will provide50- 58% of hot water needs depending on the building geographical condition and time of year.

Photo voltaic (solar panels) are green technologies incorporated into commercial building by using the buildings individuals' component i.e. Buildings hell which include energy efficient windows, lighting, insulation, foundation and the roof (Cassedy, 2004)

Photo voltaic cells are mounted on the building in grid connected pattern. The photo voltaic effects is a process in which two similar materials in close contact produce an electrical voltage when struck by right or other radiant energy (EncyclopediaBritannica, 2013) .

They are noise less, producers no emissions during operation and vary in size in a totally modular way (RebeccaBrownstone, 2004) .This green technology is beneficially in that it reduces energy use by 50% or more provide thermal insulation on the roof, protected the roof from ultra viole tradiation and reduces environmental foot print of commercial building.

2.4. Water efficiency

The major principle behind water efficiency is pre serving the existing natural water cycle and design site and building improvements to emulate the site natural pre-development hydro gel systems. Emphasize should be replace on relation of storm water and on–site infiltration and ground water recharge using method that closely emulate natural systems. Minimize the un necessary and in efficient use of portable water on site while maximizing the re cycling and re use of water, including harvested rain, storm water, and gray water (Governors Green Government Council, 2013) during site assessment effort should be made to preserve areas of the site as a natural water retention and ground water in filtration and recharges system preserve existing and natural vegetation that play vital role in natural water cycle by absorbing up to 30% of site rain water through vapor transpiration optimizing the use of water technologies such as bio-re cantation rain garden gray sawe less previous and other technologies that support on site retention and ground water recharge or vapor-transpiration (GovemosGreenGovernmentCouncil, 2013).

Water is often consume dwith little or no consideration of viability of water resources most areas of Africa face ashort age in portable water supply. Increasing water efficiency can reduce water supply and waste water treatment needs and their related cost (HauledInsulationIn, 2013)

The most basic start to water conservation is stopping leaks which account up to10% of the water in residential homes. Installing water efficient toilet will result in significant water efficiency. Toilet re presents a commercial building largest water consuming device.

Using energy certified washes with water factor below9.5 will use as little use half the amount of energy and water of non-stars washing appliance(Californiaurbanwaterconservationcouncil, 2013) Dual-flush toilet should have two bottoms that release different amount of water for either liquid or solid waste should replace older modules of toilet. These toilets use 6 liters for solid waste and 3 liters for liquid. The average flush volume is approximately 3to8 liters flush compared to older modules that use up to 13 liters in 67% saving in water.

A rain water collection system is simple green technology for the operation of residential building to conserve water use. The rain water is collected as it runs off building and would be stored in cittern s utilities needed. The water can be used water roof top garden, or treated with portable use with in the building (rainwaterharvestingorg, 2013).

Their environment benefit of this technology is reduction on load on municipal ’storm sewers and less demand on fresh water quality is by using only in digenous drought resident and hardy trees, shrubs, plant and turf that require no irrigation (installingwaterlessurinalsandaeratedfacers, 2013)

2.5Green roofs

Green roofs are light weight, engineered roofing systems with low maintenance plant accessible as a roof top garden that protect the integrity of the roof while at the same time providing many be nefit such as storm water management and energy efficiency. Energy efficiency is ensured by the reduction in heating to little fluctuation in roof temperature and instrument. Building with green roof also has increased property values(Rhall, 2009).

A green roof of building that is partially or complete covered with vegetation and agrowing medium, planted over water proofing membrane. It may also include additional layers such as root barriers and drainage and irrigation system. Container garden on roof where plant is maintained in pots are not generally considered to be true green roof although his debated roof top ponds are an other form of green which are used to treat grey water (Rodriguez, 2011).Vegetation,soil,drainagelayer,roofbarrierandirrigationsystemconstitutegreenroof(Rodrigue z, 2011).

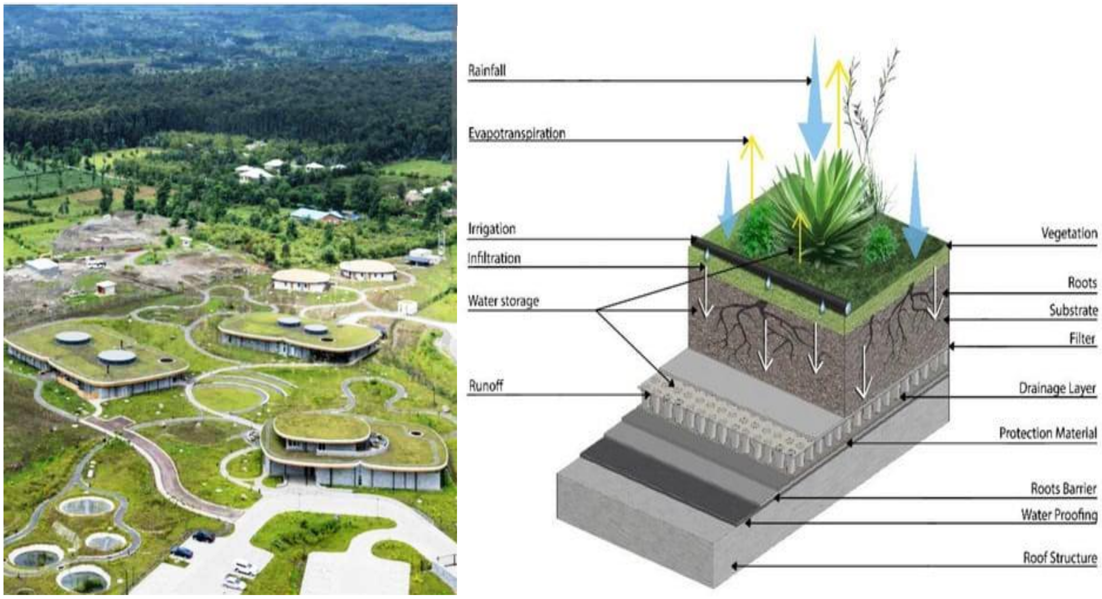


Figure2.1picturetaken at Musanze

Green roofs several purposes for abuilding such as absorbing rainwater, providing insulation creating habitat for wild life, increasing benevolence and decreasing and decreasing stress of people around the roof by providing more aesthetically pleasing landscape and helping to lower urban air temperature and mitigate the heat is land effect(EPA, 2017)

2.6. Extensive

The least costly of three systems extensive roof are extended roofs are intended as ecological roof gardens rather than amenity space. Sub strated epth srange between 0.8 and 6 inches roof vegetation typically consist of low growing herbaceous plant, such as succulent, mosses andg rasses.(Dunnet, 2008)

2.7Semi-extensive/simpleintensive

Semi-extensive roof uses the same design principles as extensive green roof but have sub strated epthrange between 4to8 inches. Some document cites 6 to 8 inched plant. Plant selection is increased to include grasses, shrubs, and coppices.(Dunnet, 2008)

2.8Intensive

The intensive green roof system essentially traditional garden at ground level soil media is generally greaterthan 8 inches. Intensive green roof can support trees, shrubs, herbaceous planting and lawn spools and water features, trees and publicity accessible space are a typically feature of an intensive roof i.e. terrace or plaza. Intensive green roof required higher capital cost and maintenance (Dunnet, 2008).

As the following table is going to summaries it blithely, and the differences between those types,

Typesofgreenroof

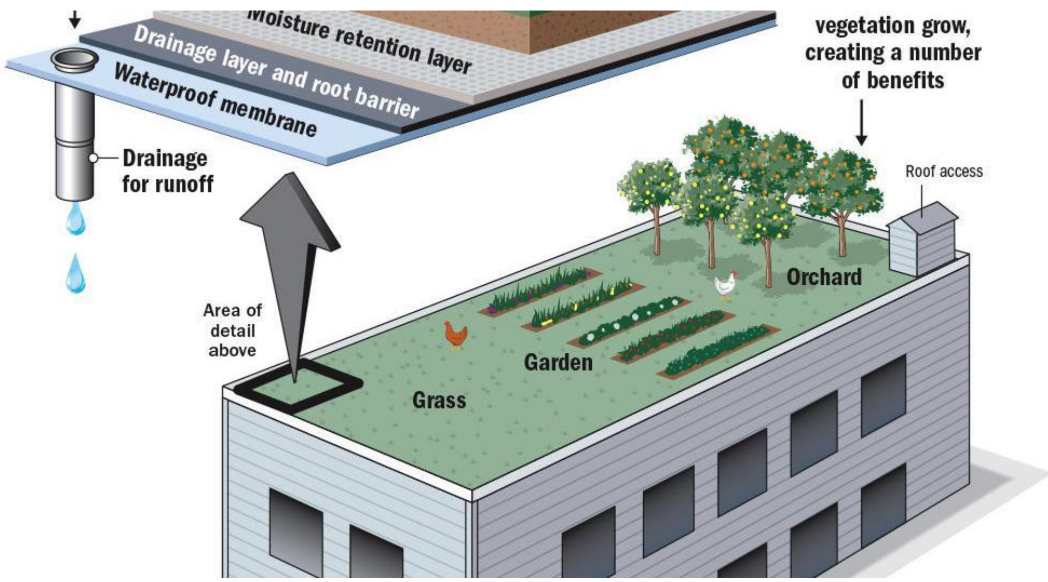


Figure2.2.Component of greenroofs

Green roof As semblies are typically composed of two systems which are: Roof base assembly and above membrane vegetated roof system. The roof based assembly made of water proofing membrane requires minimum of eight functional layers. The system layers include the vegetation, engineered fill, insulation fabric, drain age layer, rootbarrier, water proofing.(Dunnet, 2008)

2.9Vegetation

These election of green roof plants is purview of the land scope. Vegetation dead land varies between 2 and 4 post most accretion is the purview of the land scope architect roof plants are selected based on their hand in typically sedumand heat will the selected for thin roof assembly while thicker green roofs thin accommodates large structure and wide range of plants

(document, 2008)

2.10Growing media also known as engineered soil layer

Based on the plant selection the depth of growing media/soil can be determined the actual depth of the soil media will be determined by the land scope architect and or green roof special based on various parameters, including climate and soil plants psecies. The growing media should also have minimum amount of organic content to prevent settlement, minimum amount of silt and clay content, be lightweight, have good water storage characteristic, sustainable chemical parameter and have good particle size distribution (dunnet, 2008)

2.1nsulationlayer

Theinsulation layer is either installed above or below the water proofing membrane. When installed below the system is referred to as an inverted roof membrane assembly (IRMA). An inverted membrane system takes advantage of the insulation layer to protect the water proof membrane from puncture and degradation. Rigid insulation board must also have sufficient compressive strength for the load being supported. Even though agreen roof can serve as an insulating layer, it has been recognized that climates having extended periods of winter will still require an insulation layer(Dunnet, 2008).

2.12 Filter or separation fabric layer

In order to maintain the drain age and water storage capabilities of the drain age layer, anon-clogging synthetic filter fabric must be installed means that non-bio de gradable. The filter fabric mustbe constructed of a structure that resists clogging from fine soil particles (silt and clay). Typically, this filter fabric is only about 1/8 in thick. While WATER STORIN GDRAIN AGE LAYER is the drainage layer typically has two competiting with moisture during dry season and drain age layer mainly based on: drain age planets, granular,mediaanddrainagemats(Michael,2008) as described below:

Drain age plates are typically waffled rigid thermos plastics (polyethylene orpolystyrene) that are easy to install.

2.13Environmental quality and resources

Providing healthy, comfortable and productive in duce environment for including through a residential building design which afford the beat possible of induced air quality ventilation and thermal environment is major principle behind this green inte ractive (Governors Green Government Council, 2013).

This green initiative can be achieved by use of building materials, adhesive reality finishing which do not contain harb or generate or release by particulate or process contamination including volatile organic compound harmful to human healthy and we gathering energy certified ventilation system capable of effectively removing or treating in door contaminant while providing adequate amounts off reshclean make–up air to all occupants and temperature and carbon dioxide level, sothat building ventilation system can respond when space fall outside the optimum range (Cohen-Rosenthal, 2000)

Designing building envelope and environmental system that not only treat air temperature and provide adequate ventilation, but which respect all of the environment condition which affect human thermal comfort and health ,including them earn radiant temperature of interio rsurface indoor air humidity velocity and indoor air temperature (Cohen-Rosenthal, 2000).

Preventing contamination of the building during construction involves ta king steps to minimizing the creation and spending of construction dust and dirty. Prevent contamination of the building and the drainage plate system in typically.

Granular Media systems are compound of at race layer of light weight magic this granular media will typically contain porous light aggregate gradual media are several drain age conduits. Granule rain age is system typically 2 to induced thick. Depending on the type of green roof. An o fthe three system available is composed of multi-fabric mat that combines oil separation drainage, and protection function it is out draw back though is limited water storage and drain age capacity typical mat thickness are in the range of 3/8 inches(Mikael, 2008)

Protection fabric: The protection fabric is typically placed above the water proofing and root barriers membrane. This layer's role is to prevent damaged during construction and roof maintenance activities. Fabric weight between 15 and 25^{o}nceper square yard with an ominal thicknessof% inch protection fabrics also can be designed tohave water storage and capillary capabilities in older designs concrete stopping slabs were al soursed as protection layer (Osmundson, 1999).

Certain water proofing membrane such as bituminous or asphalt based require a root protection penetration porndegradation due to micro-organism.

2.14. Releases agents

Typically thickness range between 0.03 to 0.01 inches(Mikael, 2008)

Waterprooflayer: For long lasting and maintenance free life green roof water proofings election is critical water proofing and membrane should be elastic must be with stand pounded water be non-bio degradable and resident to root penetration. Water proofing can be fluid-applied as phalt based torched applied bitumen thermoplastic singleply. Or thermoset polymer based single plydue to reduction in temperature fluctuation, European studies have indicated that placing soil and plant media over awater proofing membrane can be double themembrane life span when compared to conventional roof. Thickness and weight vary(Mikael, 2008)

2.5Component of greenroof

A green roof mustbe having the following importan tthings : concrete cover membrane placed on slab, fertile soil for developing plants to grow up, way of dis placing which will be destroyed.

Green building normally minimizes the use of non-renewable construction materials and resources through efficient engineering designed planning and construction recycling of construction habits. It also maximizes the use of recycle content materials modern resources efficient engineered materials and resources efficient composed type of structural system wherever possible. Maximize the use of re-use able managed bio-based materials key strategy and technology behind green materials and resources is to identify ways to reduce the amount of materials used and reduce the amount of water generated through the implement clearly labeled dump sters for each recycle materials will ensure maximum resources efficiency (McGraw-HillConstruction, 2013)

Green building normally minimizes the use of non-renewable construction materials and other resources through efficient engineering design, planning and construction effectiveness recycling of construction debris. It is also maximize the use of recycle content materials modern resources possible maximize the use of re-usable, renewable managed by bio-based materials key strategy and technology behind the green materials and resources is to identify way sto reduce the amount of materials used reduce the amount of waste generated through implementation of construction waste reduction planadopt policy of waste equals food whereby 75% or more of all construction waste is separated for recycling and used tofeed stock for some features product providing separate Cleary labeled dump sters for each recycle material will ensure maximum resource efficiency (McGraw-HillConstruction, 2013).

Contractors should there by identify ways to use high-recycled content materials in the building structure and finishes such as blended concrete using fly ash, slag recycled concrete aggregate or other admixtures to recycled content materials such as structure, steal, ceiling, and floor tiles, cartening, carpet paddings , heathing and gypsum wallboard, Green contractor go a step further and explore the use of bio-based materials and finishes such as various type of agro-board (sheathing and or insulation board made from agri culture waste and by products including straw, wheat,bakely,soy,sunflower,peanutshells,andothermaterials)
(GovernorsGreenGovernmentCouncil, 2013)

Some structural insulated panels are now made from bio-based materials use lumber and wood product certified forests where the forest is managed and lambed is harvested sustainable practice thus ensuring sustainable forest management practices.

Leadership in energy and environment design (LEED) is an internationally recognize green building certification system proving third party verification that abuilding or community was designed and built using strategies aimed at improving performance across all the matrices that matter most energy savings, water efficiency, CO2emission reduction, improved indoor environment al quality, and stewards hip of resources and sensitivity to their impacts (Governors Green Government Council, 2013)

2.15. Environmental and socialbenefits of commercial greenbuildings

Green buildings provide a healthy, comfortable and productive indoor environment for building occupants and visitors and the best possible conditions in terms of indoor air quality, ventilation, thermal comfort, access to Natural ventilation and day lighting and effective control of the a coustic all environment as discussed in this study. Are cent Lawrence Berkley national laboratory study reported that commonly recommended improvements to indoor environments could reduce health care costs and work losses from communicable res piratory disease by 9-20 percent, among other benefits by promoting the need and use of recycling construction material a lot of stressis all eviates from extraction and utilization of environmental resources thus conservation and re use of materials and resources. As domestic fossil fuel supplies are depleted and energy resources getting expensive as each day passes, our nation becomes more dependent on sources getting expensive as each day passes, our nation become more dependent on sources from foreign countries.energy-efficiency and renewable sources green building can less esthis depend on help improve national resources security. (JeffMartin, 2007)

2.16. Financial benefit to green building

Higher selling potential in there are state sector due to health effect on in habitants' durability and easier of maintenance, environment friendly and energy efficient as sociated with green building (JeffMartin, 2007)

Saving in energy of 20-50 are common thorough energy saving technologies, integrated sustainable green initiatives. Increased value for developers and owners due to growing confidence in the industry that a high-performance green building can either capture lease premiums or present a more competitive property in an other wise tough marc green building reduce the stretch on locally infra structure capacities standard in more countries should help in there guard low utility bills due to energy and water efficient brought about by incorporating green building technologies and strategies (JeffMartin, 2007)

2.17.Advantages of greenbuilding

Green building has extensive recorded list of advantages that include: energy saving, building temperature control, roof membrane protection and life extension, Sound insulation, fire resistance, amenity space, increased property value, reduction in urban island heat is land effect, storm water rotation, air cleaning capabilities, and ecological habitat creation. Green roofs are not constructed for living purpose only, but also for numerous benefits. The major advantages of green building are going to be discussed be low one by one(JeffMartin, 2007)

2.18. Reduced urban heat island effect

The urban heat island (UHI) refers to the higher air temperature in the city center to surrounding natural land scape. The lack of vegetation covers and natural landscape in the city means the city experiences less evaporative cooling and there for eincrease the air temperature. Dark during building materials such as roof tops and pavements further absorb and trapsolar heat and these factors combine to contribute to the urban heat island (Michael, 2008)

The inclusion of green roof scan reduce UHI by introducing vegetation on to some of the hottest surface in urban areas. By means of evapo transpiration and simply cover in the roof with areas absorbing surface, temperature can be reduced (Michael, 2008).

2.19. Energy efficiency

Green roofs in crease the energy efficiency of the building envelope and reduce abuilding energy demand on space condition and there fore green house gas emission, through directs hading of the roof, evapotranspiration and improved insulation values. Green roofs are particularly effective in reducing heat entry into building in the summer. The plants shade and cool roofs. The insulation medium evaporates and further cools roof. The growing medium also acts as a thermal mass that stores solar energy during the day and release it a night (Mikael, 2008)

2.20. Air quality improvement

Plant surface obsorb air borne particles and remove them from the air. The particles off the leaves and into the growing substrate during the rain events. Green roofs can reduce summer time peak cycling demand there fore indirectly reducing CO2 emissions from power plants due to low erenergy demand. This particularly important for air quality in region that generate electricity through coal combustion (Mikael, 2008).

2.21.Aesthetic and new amenity

Green roofs not only make use of this space by providing much improve the archite ctural aesthetic of the building, there fore increasing the over all property value. Greenroofs help encourage a more thought ful approach to city by increasing amenity and greenspace, encouraging community gardens and food production and extending commercial recreation space, and increase cultivable areas. The introduction of green roof into the standard building palette creates unique a desired quality of visual significance. It has been suggested that including green eryin the city scape reduce stress and patient recovery time, increase property values and has been linked to reduction in crime (Mikael, 2008).

2.22Stormwater management

The amount of imper meable surface in an urban environment and developing is directly linked and quality of storm water run-off. Because urban and developing areas environment tend to have a low percentage of permeable surface as shown in figure5, alarger volume of storm water is through various management components like pipes, ditches , and tunnels that eventually lead to rivers, streams and lakes. This increase of run off volume as well as the increase frequency of run off causes pollution and erosion in our rivers and stream green roofs can convert in previous surfaces that absorb water and release its lowly over period o ftime. Some of water is taken up by the vegetation and release back to the at mosphere through evapo transpiration (Michael, 2008)

2.23. Fire resistance

If green roof is well designed can be successful in preventing the spread of fire.Though some plant may be less fire that others (such as occulents retaining significant amount of water versus grasses that season all dry out) layers of organic matter and even minimal moisture canbe effective in preventing thespread of fire. It is important tomaintain and provide evaporate fire breaks to limit flammability on all green roof .All green roof should be with local co des (Michael, 2008)

2.24. Biodiversity and habitat preservation

Urban sprawl has affected the health of ecological system by disrupting corridors and manipulating there courses and vegetation in natural environments. Green roof can be have an inter mediate for migration for species of insect and birds using the urban environment. The potential for height extensive greenroofs with their lack of human inter ventionare more protected and can nest on the ground. The deeper soil more insect diversity the green roof will support (Michael, 2008)

2.25Urban and developing areas Agriculture

Green roofs provide secured growing space for gardening and agriculture in urban and developing areas. They have the potential to address the balance between areas space for living and growing, an essential component of improving living quality in high density urban developing areas (Michael, 2008).

Green roofs for food production require little alteration from standardized system, but few issues need to be considered such as:

The depth of growing medium needs to be sufficient for an choring and sus taining food plants.

Water proofing membrane needs to be sufficiently protected from frequent use of gardening tools.

Fertilization may be required to sus tain nutrient used in evenly growing medi um.

Safety and quality of produce mustbe considered.

2.26Sound insulation

A green roof can be the noise level with in the building by 40-60 describe the thickness, plant type growing medium and plant coverage can be influence the effectiveness of its green roof to reduce noise levels (Mikael, 2008).

2.27Disadvantages of green roof

Disadvantages of green roof are few compared to their advantages. Here are disadvantages of green roof:

The cost of green roof is higher compared to other roofing system.

Depending up on the type green roof, maintenance will be higher.

One more disadvantages of green roof is that when they are built in places to bad weather, such as seismic zones or windy places there is a great chance of the plants not surviving.

Green roof requires much materials and equipment.

2.29Drain age and irrigation system

Drain age is most important to any field of agriculture. If too much water is present and un able to three times per year with addi tional inspection ad vise after major weather events. All drain age must remain free of vegetation and foreign objects. Interior gutters and emergency over flow hould be kept free from obstruction by either providing adrain age barrier (example: gravel barrier between the green roof and emergency over flows) or they should eequipped with inspection shaft (Michael, 2008).

For irrigation system needs be a flushed out completely before the first winter freeze it is recommended to check emitters and spray head of springs start-up and through out the season. If you have drip irrigation system hand water I tcanbe used during the plant establishing period installing or adding a main line has picket might beconsidered for additional hand water in during establishing periods, dry seasons during fall and spring while irrigation is of fand cleaning. As irrigation is made of different irrigation system should be applied according to the availability of materials and need of the owner (Mikael, 2008).

2.30Design roads and load combination

Load combination: building structures should be verified for two building condition as flow: building structure with ball roof (conventi onal roof) and building structure with saturated green roof. That means essenti ally envelops design of the building structure under maximum and minimum bases hear and over turning condition (FMGlobal, 2007)

2.31Design loads

The following is brief discussion of various loads that can be applied to green roofs so that structure engineers must consider provided comprehensive dis putting due to on date structural engineering related items for green roofs (FMGlobal, 2007)

2.32Dead loads

As dis cussed above the land scape architect has variety of green roof assemblies to choose from. Appendix provide various design load references same chapters on the FLL guide line provide additional reference design load and geometric data specified depth is recommended for future of growth media (FMGlobal, 2007)

2.33Live loads

Should be determined based on the type occupy and local building code requirements global recommends that green roofs be designed for no less than12 PSF considering live load and minimum of 20 PSF for intensive and simple intensive green roofs (MFGlobal, 2007).

2.34 Transi ent live loads

Transient live loads are contained in granular drain age materials and Geocomposites drain layers. This load is treated as live load in the building code combination while snow and rain loads should be based on the local juris diction building code requirement (FMGlobal, 2007)

2.35Wind loads

Several performance requirements related to wind up lift of membrane, soil media, wind–bornedebris and building height restrictionare discussed in FMGlobal data sheet 35

1.roof should be designed for the envelope of wind up lift on roof and saturated greenroof. While seismic loads are current recommendation appear to indicate deadload of green roof structure shall be used as part of the seismic mass. Transient live load is not included in this mass calculation (Gartner, 2008)

CHAPTER THREE: MATERIALS AND METHODS

3.0. Introduction

This chapter discusses strategies that used, a detail description of how this research was done. It was dealing with materials, tools and method used to collect data, which was analyzed before they are used. For obtaining all needed information in this research, data collection techniques used like documentation, datacollection from different sources.

3.1.Sitedescription

This project of structural design of G+1 Green commercial building is located in Kigali city, Gasabo district, Gisozi sector, musezero cell. Annual population is 75,61.

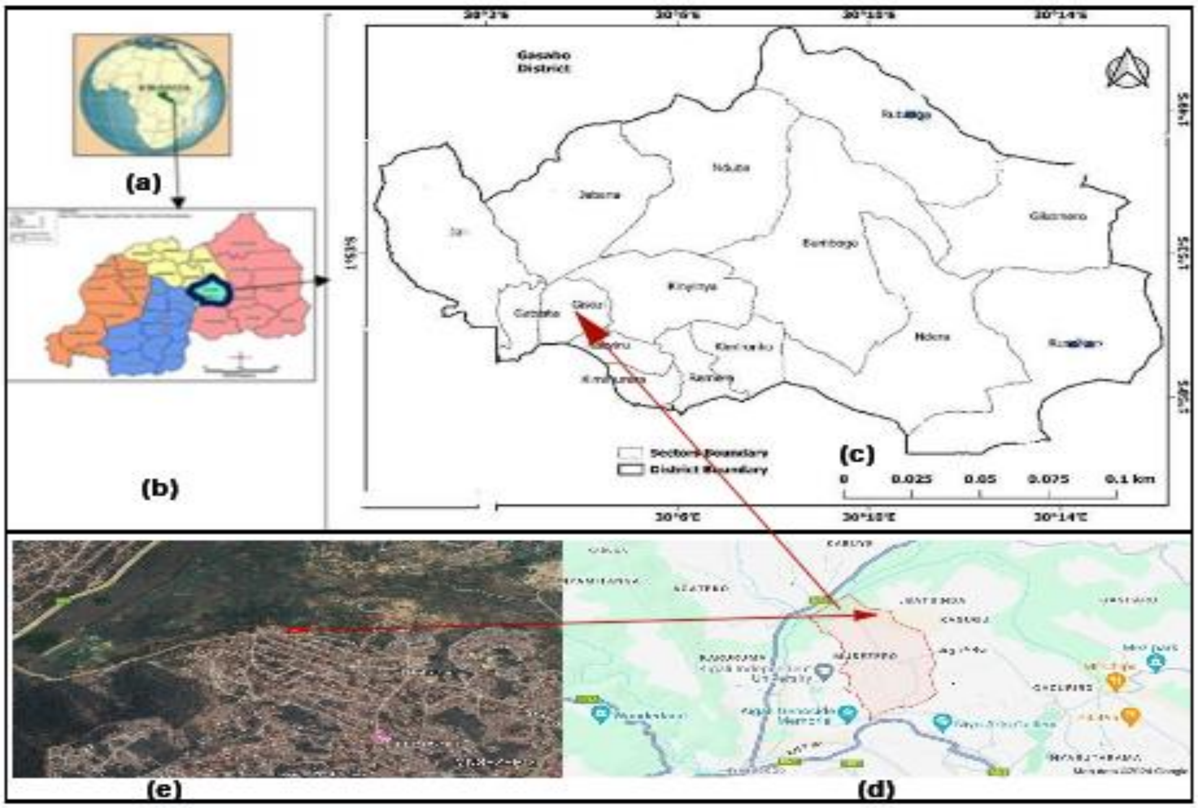


Figure 1.3: The map indicate the location of the study

3.2Materials and methods

Materials and methods are measured to achieve the research expected results that can be scientifically proved. The following materials and methods has been used:

3.2.1.Materials used

There are different of soft aware that are used such as, Archicad26, Prota structure, GIS, Google earth and Microsoft word.

3.2.1.1ArchiCAD software

Archi CAD is used for drawing different lay outs, details, plans, elevations, section and different sections. It is very use ful software for civil mechanical and electrical engineers. We also useArchiCAD for a3 D presentation of a designed building.

3.2.1.2Prota structure

This soft ware was used to analyze and design different members of the structure.

3.2.1.3 Arc GIS and Google Earth

This soft ware was used to locate the area where the project of structural design G+1 green commercial building was taking place.

3.2.2.Methods used

Site visit of the area was done for better knowing the site where the structure has to be constructed, aiming at identifying proper position of the project with reference to the neighboring one, be a ccessibility means, site topography, previous uses of site, suitability of project to the area on which the design based.

Interviews which was given to people of Gisozi sector helped to know more information about Gisozi sector and about availability of labors, infra structure, raw materials. Reading books from library, keep discussing with supervisor about relevant information related to the project based to his experience.

Internet as global server where it is easily to get information or research for different knowledge including the designing of building, was the mosthel per method to a chieve this project design.

3.3.Conceptual design procedures

According to the standards out lined in the literature review, the architectural dimensions of the commercial building that are the subject of this study were obtained and the rooms were arranged after learning the sizes of each room in accordance with their intended uses.

3.4.Architectural design

Architectural drawings are technical drawings of a building project that are used by architects and others for a variety of purposes, including developing design concepts for proposals, communicating idea concepts, persuading clients of the merits of designs, enabling the construction of a building as a record of the completed work, and creating records of buildings that already exist.

Architectural drawings were those that satisfied the ideas. The procedures used in this project included gathering information from the site and using ArchiCAD26 to produce the projects architectural design, which included specific floor plans, elevations, sections, a roof plan, and a foundation plan.

3.5.Role of architectural drawings on structural design

When converting a design into a flexible structure, architectural drawings, which form the basis of building designs, play a crucial role. As a result, they provide the structural designer with a wealth of information, including dimensions, the framing of the building, and trial sections, particularly for the roof structures and foundations. Additionally, they give structural designers information about the nature, type, and early design stage of materials.

The additional goals include transforming design concepts into alogical proposal, communicating ideas and concepts, persuading the client of the design's benefits, enabling a builder to implementing, and serving as proof of the work's completion.

3.6.Structural analysis and design

3.6.1.Structural design information

1. At 28 days old, theconcrete that would be used must have a high compressive strength. Concrete has a specific weightof 24KN/m^3 when reinforced. Except for the slab, which would have aresistance of 25N/mm^2, the concrete to be utilized would have a resistance (fc)of30N/mm^2.
2. The reinforcements that will be employed are mild steel shear reinforcement (fy) with a characteristic strength of 360N/mm^2 and hot-lolled reinforcement with a resistance strength (fy) of 450N/mm^2 for main bars.

3.6.2.Formula for reinforced concrete design

3.6.2.1Slab

The thickness of the slab (hf) lies between lx/20 and lx/40 where lx was the shorter side of the panel, using the biggest panel among others. The effective height (h_o)=thickness of slab-the clear cover (Yang, 1994).

Deadloadofslab

- Self-load = safety factor $\times 1 meter \times thickness of slab \times unit weight of concrete$
- Finish=safetyfactor$\times 1 meter \times 1 meter \times unity weight of finishes$ Totaldeadload=self-load+finishes(Ahmed&Alarabi,2011).

Liveload onslab

- Live load = safety factor $\times 1 meter \times 1 meter \times live load of materia$(Ahmed&$Alarabi$,2011)

Types of slab

Whereλ is ratio between long side(ly) and shorts ide (lx)

Bending moment

M_x= asy$\times N \times lx^2$

M_y= asy$\times N \times lx^2$

Where Mx, is moment at long side, My is the moment at the short side. As x and as y ,are coefficients related to the design of slab, N is total load on the slab and lx is shortside of slab

Required steel reinforcements

$\alpha m = \frac{M^{\pm}}{Rb \times b \times h_0^2}$

Where αm, is the coefficient related to the design of members subjected to bending moment, R bisthedesign concrete compression strength, bisthewidth of compressive area and $\lambda = \frac{ly}{lx}$ $h_o$iseffective height.

M canbe positive or negative, if positive themoment is at the bottom and if it is negative, themoment is at the top

As=$\frac{M^{\pm}}{Rs \times \eta \times h_0}$

Where as, is total cross section of steel reinforcement, R steel tensile stress,$h_o$is effective height and η is coefficient related to the design of members subjected to be nding moment (Johnson&Buckby,1975).

For cantilevers labs,

F=1.4×Fc

H=1.6×Hc

$$M^- = \frac{PL^2}{2} + FL + H \times 1.2$$

Where1.4 is the safety factor for the dead loads, 1.6 is the safety factor for the live loads, Fc is the dead loads of railing estimated to be1KN/m,Hcis the wind load estimated tobe o.5KN/m, Ms the bending moment and L is the span.

As=$\frac{M^-_{max}}{Ra \times \eta \times h_0}$

And the reinforcements in Cantilever are placed at the top

3.6.3.Beam

Compu tation of the depth of beam

$$\frac{L_{max}}{15} to \frac{L_{max}}{8}$$

Where; L max is the span between two consecutive beams (Sistaniniaetal.,2009).

Computation of webflange of the beam (bw)

0.5$\leq \frac{bw}{h} \leq 1$

Where bw is the web of flange of thebeam, h is the height f the beam

Computation of width of flange(bf)

$+bw$

Bf=,hf is the thickness of slab and d is the breadth.

$$\begin{cases} 12hf \\ \frac{1}{3} \\ \frac{d}{2} \end{cases}$$ Load on beam

- Self-weight = safety factor×$depth of the beam$×$thickness of beam$× 1$meter$×$unit weight$
- Finishes onbeam=safetyfactor×1$meter$×$thickness of the finishes$× $[(ho+d)\times 2]$×$unit weight of finishes$
- Masonryload=safetyfactor×1$meter$×$thickness of wall$×$height of wall$×$unit weight of mosonry$
- Plaster=safetyfactor×$thicknes soffinishes$×$height of wall$×1$meter$× $in\ and\ out$×$unity\ weight of finishes$
- Total dead load=self-load+finishes(Ahmed&Alarabi,2011)

Bending moment inbeam

Bending moment and shearforces due to permanently distributed loads:

$M_{max}=[\propto G+\beta Q]L^2$

V_{max}=(Ag+bQ)L

Required reinforcement in beam

$\propto_m=\frac{M^{\pm}_{max}}{Rb\times b\times h_0^2}$, then correspond ε And ŋ from themanual.

Effectiv eheight=h_o−cover

As=$\frac{M^{\pm}_{max}}{Rs\times ŋ\times h_0}$, then correspond as to the diameter of the bar.

Design for shear reinforcement in beam

$Q_{S\omega}=\frac{(V_{max})^2}{4\times \varphi b!\times Rbt\times b\times h_0^2}$, then provide the diameter

,

S=$\frac{R_{s\omega}\times A_{s\omega}\times n}{Q_{s\omega}}$, s is the spacing of stirrups,

$S\leq\begin{Bmatrix} S_{max}=\frac{0.75\varphi b!\times R_{bt}\times b\times h_0^2}{V_{max}} \\ \text{width of the web=30cm}\end{Bmatrix}$

$S_{max}$is≥30cm

3.6.4.Column

Loads on column

- Load from the slab = total deadload of slab×$influance\ areaofslad$
- $self-loadofthecolumn=safetyfactor\times are$ $aofcolumn\times heightofcolumn\times unitweight$
- $loadfromthebeam=safetyfactor\times widithofthebeam\times (length+widthofunfluencearea)\times unitweight$
- $mosonry\ walls=safetyfactor\times thicknessofwall\times 1meter\times unitweight$
- Plaster on walls = safety factor×$heightofwall\times 1meter\times thickness\ of\ finishes\times inandout\times unitweigt$
- $live\ load = liveloadofslab\times influenceareaoftheslab$

3.6.5.Load applied on the floor of the column

Ground floor part of the column up tofooting

- Self-load oftheunderground=safetyfactor×areaofcolumn×heightofundergroundcolumn×unitweight
- load=(loadfromtheslab+loadsfrombeam+masonryload+plasteronthewall+liveloadfromtheslab)×numberofstory+(self−weightofthecolumn×numberoffloor)+(self−weightof the column×numberoffloor)+(self−load of the underground column)+(load from theslab+load from the beam+liveload from slab) (Killeen&McCabe,2014).

Floorpart of the column

- loads=(loadsfromtheslab+loadfromthebeam+masonryload+plasteronthewall+liveloadfromtheslab)×$numberofstory+(self-loadoftheundergroundcolumn)+(loadfromtheslab+loadfromthebeam+liveloadfromslab)$

Steel reinforcement on thecolumn

Slender nessration($\lambda) = \frac{0.7h}{a}$

Where λistheslendernessration, hiseffective height of the column and a isthewidthofcolumn.

As=$\frac{\left(\frac{N}{\varphi}\right)-(Rb\times Ab)}{Rsc}$

Where assist otalcrosssection of the steel reinforcement, N is total load on the floor, R b is the design concrete compression strength, Ab is the area of column cross section, R sc is the design steel compression strength and φ is the coefficient used to take into account the columns lenderness and the construction in accuracies (Kempfert&Gebreselassie,2006).

3.6.6.Foun dation

Load on foundation

- Total design permanent load =designload–liveload
- Total characteristic liveload=$\frac{Total\ live\ load}{Safety\ factor\ of\ live\ load}$
- Total characteristic liveload= $\frac{total\ design\ permanent\ load}{safety\ factor\ of\ dead\ load}$
- Totalcharacteristicload=totalcharacteristic permanentload+totalcharacteristicliveload
- Estimatedweightofsoilonfoundation=10%oftotalcharacteristicload
- Totalloadonsoil=totalcharacteristicload+estimated weightofsoilonfoundation(Kempfert&Gebreselassie,2006).

Therequiredareaoffoundation

Af=$\frac{total\ load\ on\ soil}{design\ bearing\ capacity}, Where\ Af\ is\ area\ of\ foundation$

Designpressure

- P=$\frac{Nc}{Af}$ $Wh \quad P\ is\ pressure\ and\ Nc\ is\ load \quad column \quad , \quad ere \quad on$
  .

Checkingofshearforce

- TheshearforceQ≤0.54×Rbt×Ab,$WhereQisshearforce$,□Q=P×bf(lc−ho),

Where P is pressure, b fis the length of foundation, lc is the distance from the effective height to the end of

- lc=$\frac{bf}{2}\times\frac{bc}{2}$, $where\ bc\ is\ the\ width\ of\ the\ column$.

Checking for punching shear

- Qf=Nf-Δq≤Rbt×Ab,

WhereOfispunchingshear,Nf is the load transmitted by thecolumn to the foundation andΔ$qisthebalancingshearforce$.

- Qf=p×(ac+2h_0)^2,
- Ab=um×ho,where umisaverage perimeter
- Um=2(ac+bc+2ho),

Where acist h ewidth of colu mn,bc is the length of column,

Moment calculation

$M^{max} = \left(\frac{p\times af}{2}\right)\times\left(\frac{p\times af}{2}\right)^2$,

WhereM_{max} is the maximum moment, p is thepressure, af is thewidth of foundation, b fis the length of foundation and bc is thelengthofthecolumn.

As=$\frac{M}{0.9\times ho^2\times b}$

Where M is maximum moment hoiseffective height of foundation and Rsisdesign steel tensile stress.

3.5.8.Stair

Load on stair

Deadload

- Deadload=safetyfactor×$equivalentthickness$×1$meter$×$unitweight$
- Finishes=safetyfactor×$unityweightoffinishes$

- Totaldeadload=self-load+finishes(Ahmed&Alarabi,2011).
- Liveload=safetyfactor×$liveloadofmateria$(Ahmed&$Alarabi$,2011).

Required steel reinforcement int hestair

$$\alpha m = \frac{M}{Rb \times h_0^2 \times b}$$

Where αm is coefficient related to the design of members subjected to bending moment, R b is the design concrete compression strength, b is the width of the compressive area, ho is effective height, m can be positive or negatives oifM is positive, the moment is at the bottom and ifM is negative themoment is at the top.

As=$\frac{M_{max}^{\pm}}{Rs\times\eta\times ho}$

Where As is totalcrosssection of steel reinforcements, Rs is design steel tensile stress, ho effective height, and η is coefficient related to the design of members subjected to bendingmoment.

CHAPTER FOUR: RESULTS AND DISCASSION

4.0. Introduction

This chapter focused on the results and discussions of the structural

Design of a green commercial building.

4.1. Architectural design

From the architectural design, the out come was always drawings which show the designed building in different views. From its top, from all the sides as well as a perspective view showing it in three dimensions combined together.

In the arrangement of rooms, room size standard should be take into consideration. According to the standard the rooms for shops and other rooms for offices have been given enough size for creating the ventilation and other accessibility. The designed structure was including with the following features: six teen rooms for shops, four rooms offices, one show room and balcony.

Figure 4.1: The perspective of designed building

Description of commercial building

The commercial building of two floors has a gross floor are a 560.68m^2 in the plotof40m*20m. thad 16rooms for shops, 4rooms for offices, show room, 6 toilet and balcony.

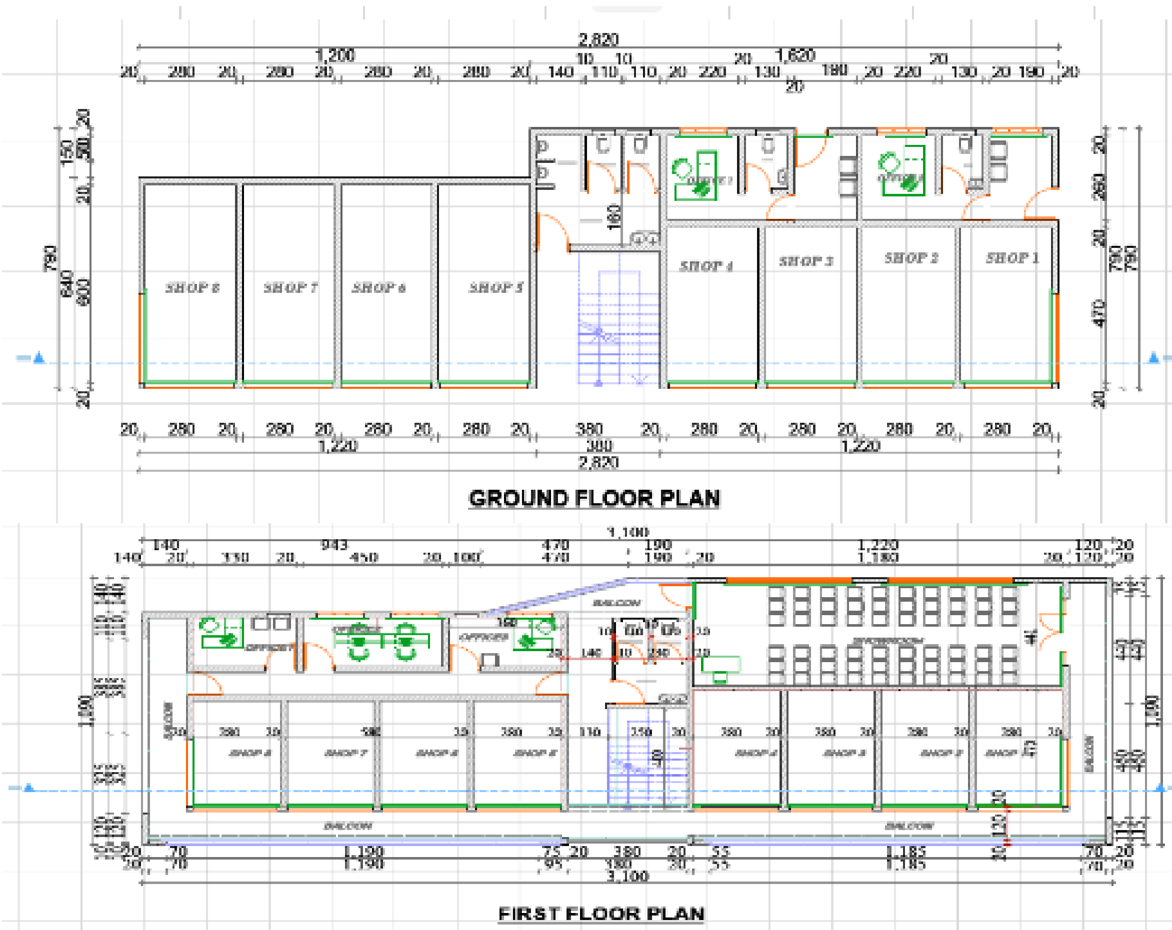


Figure 4.2: Floor plans of the building

4.2. Structure design of elements

The objective of the structure analysis to obtain a set of internal forces and moments through out the structure which are equilibrium with the design loads for the required loads combinations. The building carries distributed load (dead load and live load) over the spans. From a live load point of view, structures need 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 be with stand the worst combination of these loads. The design load combination is obtained by multiplying the characteristic loads by appropriate partial factors of safety.

The complete design of this structure has been broken down according to the structure elements; slab as horizontal plate element to carry lateral load designed, Beam as second element to carry lateral loads from slab was designed, Columns, footings, and stairs also were designed.

Table 4.1:Design elements information

DESIGN INFORMATION	
Design software	Prota stature2021(structural design software)
Design codes:	BS8110:Part1:1997&Part2:1985/BS6399:Part1:1984 ,for Wind and seismic forces:ASCE7-10
Design Strengths:	**Concrete, fcu=25N/mm^{2}ForBeamandSlab** **Concrete, fcu=30N/mm^{2}ForColumn**
Exposure condition:	**High-tensile Steel, fy=500N/mm^2** **Stirrups,fyv=250N/mm^2(links)**
General Loading Condition:	Mild for all elements. Cover:25mm for beams and columns, 25 mm for shear walls (L-type corner columns) Unit weight of masonry=18kN/m^3 Unit weight of wall finishes=20kN/m^3

	Unit weight of Reinforced concrete=24kN/m^3 Basic span-effective depth ration=26 Liveload:3KN/$m^2$for Kitchen and balcony Live load: 4KN/m^2 for sitting room Live load:2KN/$m^2$for Bed Room and toilet Loadfactor:1.4fordeadloadand1.6forliveload

The complete design of building structure has been broken down into following element:

Slab: horizontal plate element carrying lateral loads

Beams: horizontal members carrying lateral loads

Columns: vertical members carrying primary axial load but generally subjected to axial load and moment walls vertical plate elements resisting vertical, lateral or in plane loads.

Foundations: parts or strips supported directly on the ground that spread the loads from columns or walls so that they can be supported by the ground without excessive settlement.

Stair: it is a support consisting of a place to rest the foot while ascending or descending a stairway.

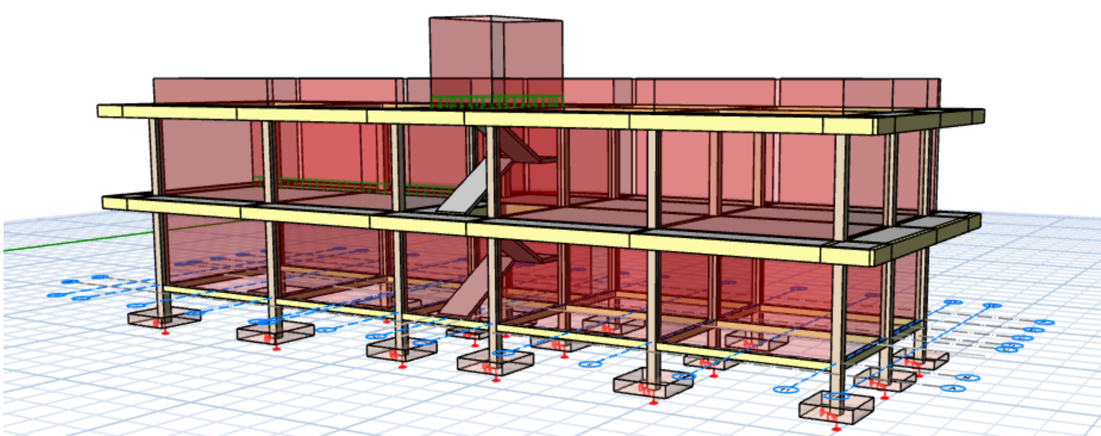


Figure 2.3: Structural model of designed commercial building:

4.2.1Slabelementdesign

Slab is horizontal plate element carrying lateral loads. They 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, and flat slabs carried on columns and edge beams or walls. The analysis and designing of slab was carried out using strip method.

Designstrips: are used to create regions with in a slab where design cuts will automatically be created and flexural reinforcing bars will be designed. If the moment varies along the length of a design strip, then the individual design cuts will show a varying amount of moment demand at each section. The results for the entire design strip will be governed by the maximum moment demand at an individual design cut. The same number and size of reinforcing bars will be used for the entire design strip, so this should be considered when defining the boundary for a particular strip. If a design strip is drawn over various slab thick ness, each design cut with in the design strip will use the thinnest thickness that particular cut inter sects.

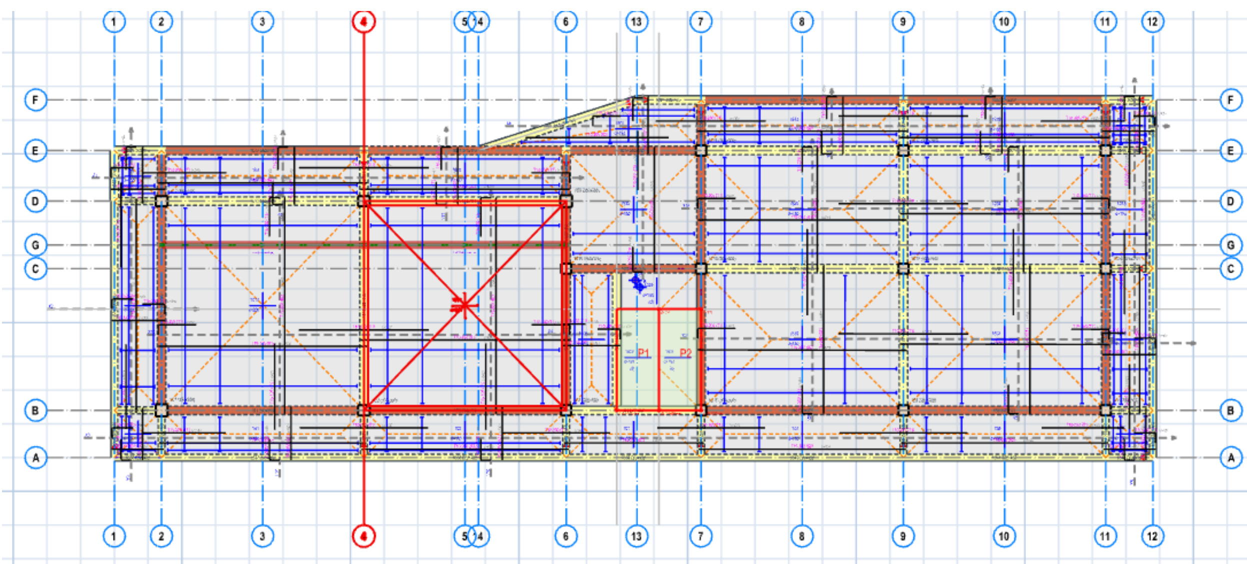


Figure 4.4: Critical panels

Analysis and design of floor slabs

LEGEND:

d/h=Slab Effective/Total Depths(d=h-cover)

g/q=Dead/Live Loads (not factored)

L1=Width of the Slab Along the strip Direction

L2=Width of the Slab Perpendicular to the Strip Direction

C=Moment Coefficient M=Cp/L^2

M-span=Ultimate span Moment

M-sup=Ultimate support Moment

Mc=Balanced support Moment

As=Steel Area (Required/Supplied)

SlabStrip:X18--Storey:1

Materials:C20/25/Grade 460(Type2)

TypegL1C-supC-spanAs

Slab d/hqL2M-supM-spanReq/Sup STEELBARS

(mm) (kN/m2) (mm) (kN.m) (kN.m) (mm2)

Support Mc=2.8Support As=295.20/392.70 Sup Top:T10-200(T1)

1S20111.6406000.000.03300.0253295.2/392.7

170/2002.5006200.0024.118.5StrBot:T10-200(B1)

Deflection Check :L/d=35.29<48.97***Sufficient***

Support Mc=24.1SupportAs=373.03/392.70SupTop:T10-200(T1)

1S21111.6406000.000.03300.0253295.2/392.7

170/2002.5006200.0024.118.5StrBot:T10-200(B1)

Deflection Check :L/d=35.29<48.97***Sufficient***

Support Mc=2.8SupportAs=295.20/392.70SupTop:T10-200(T1)

Slab strip:Y18--Storey:1

Materials:C20/25/Grade 460(Type2)

TypegL1C-supC-spanAs
Slab d/hqL2M-supM-spanReq/Sup STEELBARS
(mm) (kN/m2) (mm) (kN.m) (kN.m) (mm2)

Support Mc=0.4SupportAs=221.40/392.70SupTop:T10-200(T1)

1S218.3501400.000.10000.0860221.4/392.7
120/1502.5006000.003.12.6StrBot:T10-200(B1)
Deflection Check :L/d=11.67<52.0***Sufficient***

Support Mc=20.6SupportAs=509.17/628.32SupTop:T10-125(T1)

1S21111.6406200.000.03200.0240295.2/392.7
160/2002.5006000.0023.417.5StrBot:T10-200(B2)
Deflection Check :L/d=38.75<47.99***Sufficient***

Support Mc=2.6SupportAs=295.20/392.70SupTop:T10-200(T1)

4.2.3Beam design

Beams are horizontal structural elements designed to carry lateral loads. Floor beams in a reinforced concrete building are normally designed to resist load from the floor slab, their own self-weight, the weigh to fthe partitions

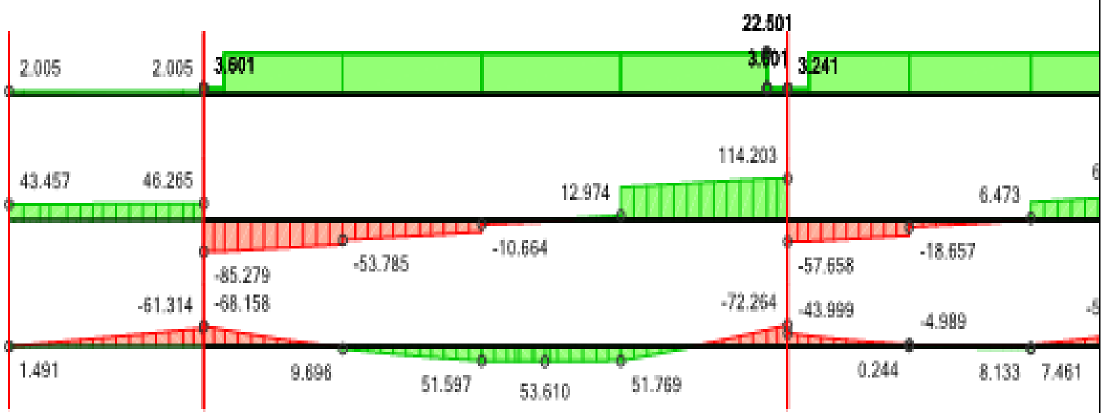
Axis:7 Storey:1

Materials :C20/25/Grade460(Type2)(Links:Grade460(Type2))ConcreteCover:25.0mm

Diagrams

Bending

	1B28
B_w x H(mm)	
Flange B_f x H_f (Left) (Right)	---
Top edge	
M(kN.m)	15.5
d(mm)	411.0
K/K'	0.12
x(mm)	45.7
$A_s(mm^2)$	0.00
$A_s'(mm^2)$	0.00
$A_{s,min}(mm^2)$	0.00
Bottom edge	
M(kN.m)	1.5
d(mm)	392.0
K/K'	0.01
x(mm)	43.6
$A_s(mm^2)$	0.00
$A_s'(mm^2)$	0.00
$A_{s,min}(mm^2)$	0.00



Shear and torsion design

V_d(kN)	44.3		46.3	85.3		114.2	57.7		110.8
v(MPa)	0.54		0.56	0.74		0.99	0.50		1.01
v_c(MPa)	0.41		0.52	0.45		0.45	0.45		0.68
v_{Max}(MPa)	4.00		4.00	4.00		4.00	4.00		4.00
V_{nom}(kN)		113.8			137.6			143.7	
T_d(kN.m)		0.1			1.0			0.1	
v_t(MPa)		0.00			0.00			0.00	
$v_{t,min}$(MPa)		0.00			0.00			0.00	
$b_{support}$(mm)	0.0		900.0	0.0		1000.0	0.0		1000.0
Links			**1T8-100**	**1T8-100**	**1T8-200**	**1T8-100**	**1T8-100**	**1T8-200**	**1T8-100**

Deflection check

L/d	3.41≤8.92√	9.11≤39.32√	7.59≤56.65√

Steel areas (mm²)

Required									
Top Edge			410.38	394.48	0.00	420.01	251.71	274.65	971.61
Bottom Edge			123.11	118.34	306.03	126.00	75.51	46.43	291.48
Supplied									
Top Edge			461.81	461.81	226.19	461.81	461.81	339.29	1608.50
Bottom Edge			226.19	339.29	339.29	339.29	339.29	339.29	493.23
Steel bars									
Top Bars					**2T12**			**3T12**	
Top.Sup.Bars			**3T14**	**3T14**		**3T14**	**3T14**		**4T16**
Top.Sup.Bars									**4T16**
Bottom Bars		**2T12**			**3T12**			**3T12**	
Bottom Bars									
Bot.Sup.Bars									**1T14**
SideBars									

4.2.3Design of column

A column is a vertical rigid structure element which carries the axial loads from roof, slabs and beams, it occurs as a compression member which transmits the applied loads acting on the structural down to the foundation.

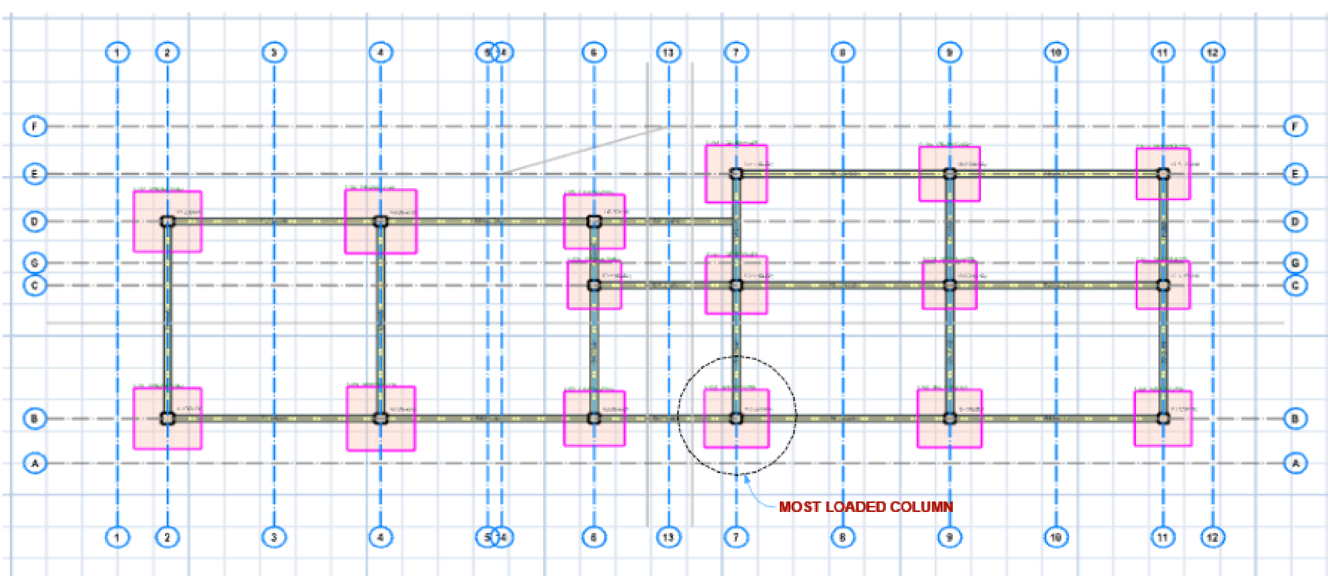
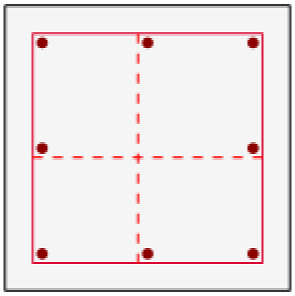


Figure 4.5: Most loaded column channel

1C17 (300/300)

Materials: C20/25/ Grade 500) (Links:Grade250)

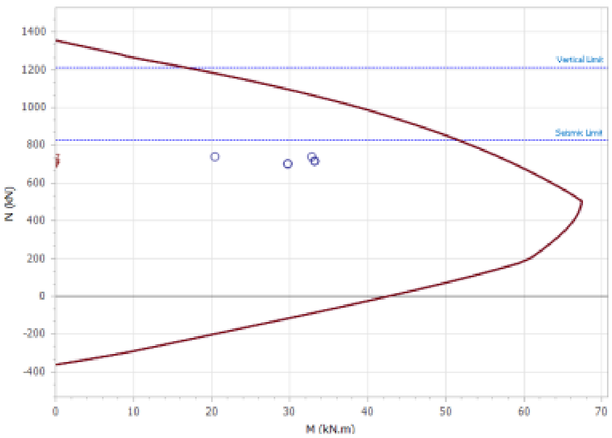
Section



Combinations

No	N_{Top} (kN)	M_{1Top} (kN.m)	M_{2Top} (kN.m)	N_{Bot} (kN)	M_{1Bot} (kN.m)	M_{2Bot} (kN.m)
1	728.7	-3.2	26.0	739.3	5.7	-13.6
2	706.1	-3.7	26.4	716.7	5.3	-13.7
3	694.4	-1.8	23.1	705.0	4.5	-12.2

InteractionDiagram



Critical Loading:1-(G+Q)

		Min	Design	
N	736.4	-	736.4	kN
M_{11}	5.9	11.0	0.0	kN.m
M_{22}	26.0	11.0	32.9	kN.m
N_{Max}	825.0			

ConcreteCover=25.0mm

(BS8110-Cl.3.8.4.5)

N/bhFcu=0.327

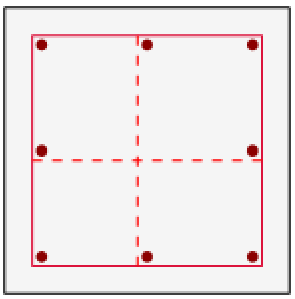
Beta=0.62

Shear						Rebars		
$V_{d(1/2)}$=	11.5/2.7	kN	ShortColumn...			As(Req):	%1.00$_{(min)}$	900.00mm^2
$v_{c'(1/2)}$=	1.12/1.27	N/mm^2	L_{e1}/b_1=	8.3<15.0	√	As(Sup):	%1.01	904.78mm^2
$v_{(1/2)}$=	0.13/0.03	N/mm^2	L_{e2}/b_2=	8.2<15.0	√			
			$M_{Add(1)/2)}$=	0.0/0.0	kN.m	**8T12**		
Links=T8-125								

2C17 (300/300)

Materials:C20/25/Grade500), (Links:Grade250)

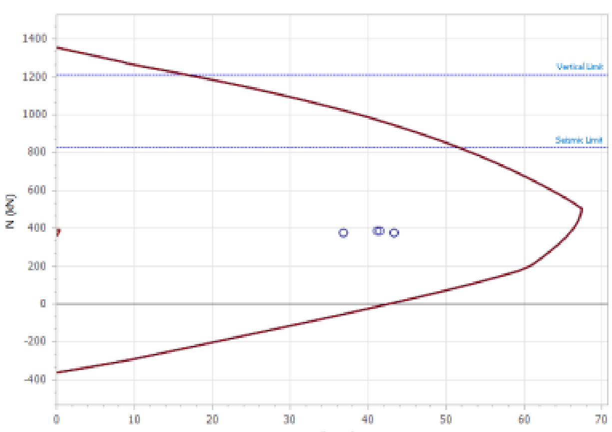
Section



Combinations

No	N_{Top} (kN)	M_{1Top} (kN.m)	M_{2Top} (kN.m)	N_{Bot} (kN)	M_{1Bot} (kN.m)	M_{2Bot} (kN.m)
1	263.8	-6.9	2.3	387.9	-6.4	-35.9
2	260.6	-7.7	2.9	378.9	-3.2	-37.1
3	252.3	-3.9	-0.8	376.6	-6.9	-31.3

Interaction Diagram



Critical Loading:2-((G+Q)p1)

		Min	Design	
N	376.1	-	376.1	kN
M_{11}	-5.9	-5.6	0.0	kN.m
M_{22}	-37.0	-5.6	-41.8	kN.m

N_{Max} 825.0

ConcreteCover=25.0mm

(BS8110-Cl.3.8.4.5)

N/bhFcu=0.167

Beta=0.81

Shear						Rebars		
$V_{d(1/2)}$=	20.9/3.2	kN	ShortColumn...			As(Req):	%1.00$_{(min)}$	900.00mm^2
$v_{c'(1/2)}$=	0.96/0.93	N/mm^2	L_{e1}/b_1=	7.5<15.0	√	As(Sup):	%1.01	904.78mm^2
$v_{(1/2)}$=	0.24/0.04	N/mm^2	L_{e2}/b_2=	7.3<15.0	√			
			$M_{Add(1)/2)}$=	0.0/0.0	kN.m	**8T12**		
Links=T8-125								

4.2.4.Design of the foundation

A building is generally composed of a super structure above the ground and a structure which forms the foundations below ground. The foundation stransfer and spread the loads from a structure's columns, roof and walls, into the ground. The safe bearing capacity of the soil must not be exceeded, other wise excessive settlement may occur, resulting in damage to the building and its service facilities or affect the overall stability of a structure.

The general design procedure involves accessment of the soil bearing pressure, examination of levels around the structure, calculation of transmitted loads and moments, calculation of the required plan are and then the required foundation depth and provided reinforcement.

Symbols and Abbreviations

N : **Axial Load of combination**
∑N : Total Axial Load
TW : Total Weight of footing
h : Footing depth
h_{taper} : Taper Height
Ecc_1 : Column Eccentricity in x direction
Ecc_2 : Column Eccentricity in y direction
$\sum M_x$: Total Moment in x direction
$\sum M_y$: Total Moment in y direction

V_{pd} : **Punching Demand**
V_{pc} : Punching capacity
V_{pd-cf} : Punching demand (on column Face)
V_{pc-cf} : Punching capacity (on columnFace)

V_{pd-ep}	:	Punching demand (on effective Perimeter)
V_{pc-ep}	:	PunchingCapacity(on effective Perimeter)
σ_{soil}	:	Soil Stress
u_p	:	Effective Perimeter
B_{EPx}	:	Width of effective perimeter in X direction
B_{EPy}	:	Width of effective perimeter in X direction
d_{sect}	:	Distance from column face to effective perimeter edge
d	:	Effective Depth

V_{dx-cf}	**:**	**Shear Force on Column Face, X- Direction**
V_{dy-cf}	:	Shear Force on column Face, Y-Direction
V_{dx-d}	:	Shear Force on Location d Away From Column Face ,X-Direction
V_{dy-d}	:	Shear Force on Location d Away From Column Face, Y-Direction
d_{v1}	:	Distance from Column Face to Footing Edge
d_{v2}	:	Distance from Location d Away From Column Face to Footing Edge
σ_{cf}	:	Soil stress on column face
σ_c	:	Soil stress at nearest corner
σ_{max}	:	Max. corners tress

Design Summary (F-1C17)

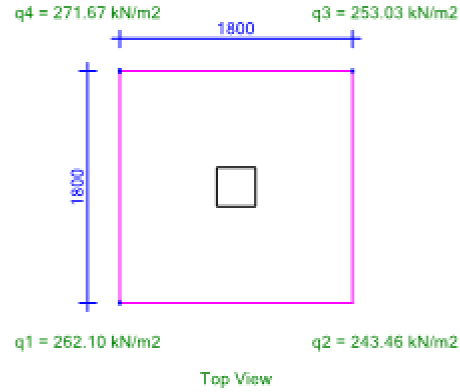
Geometric Properties and Materials

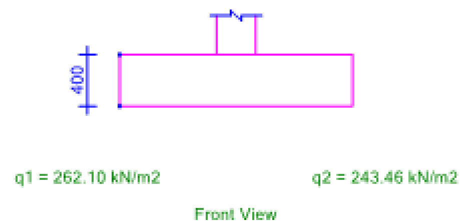
Footing Materials	
Concrete Material	C20/25
Rebar Material	Grade500

Geometric Properties	
B_X	1800.00mm
B_Y	1800.00mm
Height	400.00mm
Taper Height	0.00mm

Corner Stresses	
Lower-LeftCorner	262.10kN/m2
Lower-RightCorner	243.46kN/m2

Upper-Right Corner	253.03kN/m2
Upper-Left Corner	271.67kN/m2





Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb#1	739.3kN	11.3kN	-2.5kN	-13.6kN.m	5.7kN.m
Comb#2	716.7kN	11.5kN	-2.6kN	-13.7kN.m	5.3kN.m
Comb#3	705.0kN	10.1kN	-1.8kN	-12.2kN.m	4.5kN.m

SoilS tress check

Total footing, soil and pedestal weight is calculated.

Member		Volume(m3)	UnitWeight(kN/m3)	Weight(kN)
PadFooting	:	1.296	24	31.104
Soil	:	3.564	18	64.152
Total	:			95.256

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x=M_x+V_x(h-h_{taper})+Ecc_1N$

$\Sigma M_y=M_y+V_y(h-h_{taper})+Ecc_2N$

Corner stresses,

$\sigma_1=\Sigma N/L_xL_y-6\Sigma M_x/(L_xL_y^2)-6\Sigma M_y/(L_x^2L_y)$

$\sigma_2=\Sigma N/L_xL_y+6\Sigma M_x/(L_xL_y^2)-6\Sigma M_y/(L_x^2L_y)$

$\sigma_3=\Sigma N/L_xL_y+6\Sigma M_x/(L_xL_y^2)+6\Sigma M_y/(L_x^2L_y)$

$\sigma_4=\Sigma N/L_xL_y-6\Sigma M_x/(L_xL_y^2)+6\Sigma M_y/(L_x^2L_y)$

Comb	**ΣN(kN**	**ΣMx(kN.m)**	**ΣMy(kN.m)**	**σ1(kN/m2)**	**σ2(kN/m2)**	**σ3(kN/m2)**	**σ4(kN/m2)**
Comb#1	834.51	-9.06	4.65	262.10	243.46	253.03	271.67
Comb#2	811.93	-9.14	4.28	255.59	236.79	245.60	264.40
Comb#3	800.29	-8.13	3.82	251.44	234.71	242.57	259.30

Demand	**Capacity**	**Status**
MaximumSoilStress:271.67kN/m2	AllowableMaximumSoilStress:280.00kN/m2	√

EccentricityCheck

Comb	**Direction**	**Moment(kN.m)**	**AxialLoad(kN)**	**Eccentricity(M/N)**	**Limit(L/6)**	**Status**
Comb#1	X	-9.06	834.51	10.86mm	300mm	✓
	Y	4.65	834.51	5.57mm	300mm	✓
Comb#2	X	-9.14	811.93	11.26mm	300mm	✓
	Y	4.28	811.93	5.28mm	300mm	✓
Comb#3	X	-8.13	800.29	10.16mm	300mm	✓
	Y	3.82	800.29	4.78mm	300mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004(6.4.3)

$Vpd=\sigma_{soil}*A_{eff}*\beta$

$\sigma_{soil}=\Sigma N/L_xL_y$

$A_{eff}=L_xL_y-B_xB_y$

$\beta=1$

Punching capacity will be calculated according to EN 1992-1-1:2004(6.4.4)

(6.47)$v_{Rd,c1}=C_{Rd,c}k(100\rho_l f_{ck})$^(1/3)+$k_1\sigma_{cp}$

k=1+(200/d)^(1/2)

k=1.76,

$\rho_l=(\rho_{lx}\rho_{ly})$^(1/2)*$\rho_f$,$\rho_{lmin}$=0.02

ρ_{lx}=0.0019,ρ_{ly}=0.0019,ρ_f=1,

ρ_l=0.0019,

$\sigma_{cp}=\Sigma N/L_xL_y=0.25N/mm^2$

$C_{Rd,c}$=0.12,k_1=0.10

$v_{Rd,c1}=0.38N/mm^2$

$v_{min}=0.035k$^(3/2)f_{ck}^(1/2)+$k_1\sigma_{cp}$

$v_{min}=0.43N/mm^2$

$v_{Rd,c}=Max(v_{Rd,c1},v_{min})=0.43N/mm^2$

$v_{Rdmax}=0.5(0.6(1-(f_{ck}/250)))f_{cd}$

$V_{pc-cf}=v_{Rdmax}u_pd$,

$V_{pc-ep}=v_{Rd,c}u_pd$,

$u_p=2(B_{EPx}+B_{EPy})=6736$

$B_{EPx}=B_x+2d_{sect}=1684$

$B_{EPy}=B_y+2d_{sect}=1684$

$d_{sect}=2d_{eff}=692$

V_{pc-cf}=1868kN

V_{pc-ep}=1168kN

Comb	**ΣN(kN)**	**σ_{Soil}(kN/m2)**	**Vpc-cf(kN)**	**Vpd-cf(kN)**	**D/C-cf**	**Vpc-ep(kN)**	**Vpd-ep(kN)**	**D/C-ep**
Comb#1	834.51	257.57	1868.40	811.33	0.43	1170.62	104.09	0.09
Comb#2	811.93	250.59	1868.40	789.37	0.42	1170.62	101.28	0.09
Comb#3	800.29	247.00	1868.40	778.06	0.42	1170.62	99.82	0.09

Comparisonat	**Demand/Capacity**	**Status**
EffectivePerimeter	104.1kN/1170.6kN	√
ColumnFace	811.3kN/1868.4kN	√

ShearCheck

$V_{dx-cf}=\sigma_{cf}d_{vx1}L_y+((\sigma_{max}-\sigma_{cf})d_{vx1}L_y/2)$

$V_{dy-cf}=\sigma_{cf}d_{vy1}L_x+((\sigma_{max}-\sigma_{cf})d_{vy1}L_x/2)$

$V_{dx-d}=\sigma_{cf}d_{vx2}L_y+((\sigma_{max}-\sigma_{cf})d_{vx2}L_y/2)$

$V_{dy-d}=\sigma_{cf}d_{vy2}L_x+((\sigma_{max}-\sigma_{cf})d_{vy2}L_x/2)$

OnColumnFace,

Comb	Demand(kN)	X-Direction Capacity(kN)	Status(kN)	Demand(kN)	Y-Direction Capacity(kN)	Status(kN)
Comb#1	364.06	588.64	✓	361.51	588.64	✓
Comb#2	354.47	588.64	✓	351.66	588.64	✓
Comb#3	347.84	588.64	✓	345.35	588.64	✓

On"d"DistanceAwayFromColumnFace,

Comb	Demand(kN)	X-Direction Capacity(kN)	Status(kN)	Demand(kN)	Y-Direction Capacity(kN)	Status(kN)
Comb#1	278.87	588.64	✓	280.73	588.64	✓
Comb#2	271.49	588.64	✓	273.11	588.64	✓
Comb#3	266.38	588.64	✓	268.12	588.64	✓

Comparison at	Demand/Capacity	Status
Column Face in X-Direction	364.1kN/588.6kN	√
Column Face in Y-Direction	361.5kN/588.6kN	√
Effective Perimeter in X-Direction	278.9kN/588.6kN	√
Effective Perimeter in Y-Direction	280.7kN/588.6kN	√

Bending Reinforcement Check

Comb	Md_x(kN.m)	RequiredAs_x(mm2)	Md_y(kN.m)	RequiredAs_y(mm2)
Comb#1	1368.60	1194.92	1362.21	1200.52
Comb#2	1332.34	1194.92	1325.32	1200.52
Comb#3	1307.17	1194.92	1300.94	1200.52

Comparison of	DesignMoment	SelectedRebar	Required/Provided	Status
Reinforcement Area inX-Direction	136.2kN.m	10ϕ14/200.0mm	1194.92mm2/1385.44mm2	√

ReinforcementAreainY-Direction	136.9kN.m	10ϕ14/200.0mm	1200.52mm2/1385.44mm2	√

4.2.5Design of stair

A stair is a set of steps leading from one floor of a building to an other, typically inside the building. The room or enclosure of the building, in which the stair is located, is known as stair case. This stair contains threeparts: rise, tread and waist.

The opening or space occupied by the stair is known as a stair way Assume R=150~175mmandT=200~250mmh=$\frac{H}{2}=\frac{350cm}{2}$=175cm,

Stairs with a Simply Supported Landing By Outer Longer Edge

Stair Parameters:

Section of The Step	:	3500.0	mm
Stair Width (b):	:	1250.0	mm
Storey Landing Width (bSK)	:	1250.0	mm
IntermediateLandingWidth(bSA):	:	1250.0	mm
Number of Steps(n):	:	18	
Step Width(a):	:	250.0	mm
Step Height(Rise)(s):	:	175.0	mm
Stair Hole Width(bK):	:	100.0	mm
Plate Thickness(Stair)(dK):	:	170.0	mm
Plate Thickness(Landing)(dS):	:	170.0	mm
Stair Plate Angle	:	34.99	deg
Support Width(bM):	:	250.0	mm
Concrete Cover	:	30.0	mm

Deflection Check:

Span	(L)	4750.0	mm
Section Depth	(d)	140.0	mm
L/d		33.93	

Loads

At The Stair Arms:	4.980	1.500	2.500
At The Landings:	4.080	1.500	2.500

Section Forces

Left Support	33.17	kN/m

Right Support 33.17 kN/m

Bending Moment

Bending Moment 42.1 kN.m

Reinforcement Design

#		Moment(kN.m)	SteelArea(mm2)	SelectedSteelBars
1	1stSlopedPlate-PrimaryRebar(Top)	42.1	883.41	11T12-110
1	1stSlopedPlate-PrimaryRebar(Bottom)	42.1	883.41	11T12-110
2	1stSlopedPlate-DistributionRebar(Top)	0.0	176.68	17T8-260
2	1stSlopedPlate-DistributionRebar(Bot)	0.0	176.68	17T8-260
2	LandingPlateLateralRebar(Top)	0.0	176.68	6T8-240
2	LandingPlateLateralRebar(Bot)	0.0	176.68	6T8-240

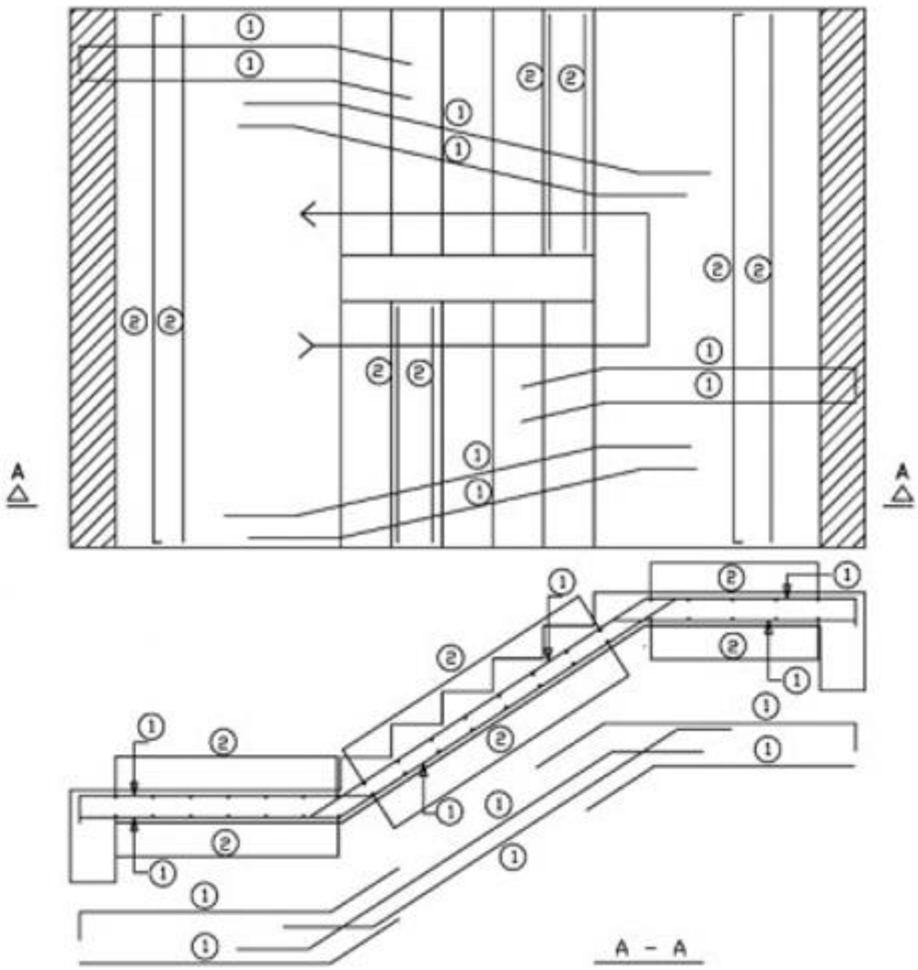


Figure 4.6: Reinforcement arrangement in stair

CHAPTER FIVE:CONCLUSION AND RECOMMENDATIONS

5.1Conclusion

As conclusion the design of green commercial buildings contributes in the protecting environment by promoting the uses of energy efficiently, and conserve water. It also decrease environmental impact by reducing surface run of fand the heating effect. Green buildings help to reduce the depletion of natural resources and improve standards through out time.

The structural design was carried out by Archicad 26 and structural design of members (slab, column, beam, footings and stairs) has been achieved by using Prota structure. The objectives were achieved and the designed building is safe and economic in consideration of this study scope and limitations, sections and reinforcement needed are provided and shown in the above chapter

5.2.Recommendations

I every one in every sector is recommend that Choosing design a green building is not just a choice but along lasting dedication to up hold the virtues of natural and sustainable living. Green buildings are a responsible decision to prevent capital depletion and conserve nature for our future genera tions.

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APPENDICES

AppendixA:3D Model of a building

a

Appendix B: Foundation elevation