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DEPARTMENT OF CIVIL ENGINEERING

OPTION: CONSTRUCTION TECHNOLOGY

FINAL YEAR PROJECT

DESIGN OF REINFORCED CONCRETE WATER STORAGE TANK CASE STUDY: NYANZA DISTRICT, BUSASAMANA SECTOR.

Sub[illegible] a in Construction Technology

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Kigali, **September**, 2024

DECLARATION

I, IRADUKUNDA Franck hereby declare this project of "**Design of reinforced concrete water storage tank"** located in BUSASAMANA Sector/ NYANZA District, submitted in partial fulfillment of the requirement for the Advanced Dplоma in Civil engineering department, Option of construction technology at ULK POLYTECHNIC, is My original work and also has not been presented anywhere, Either University or any other institution of higher learning for academic or any other purpose for the award of thesame specification.

Student names: IRADUKUNDA Franck

Date:………./……………../2024

Signature ………………

CERTIFICATE

This is to certify the project work known as **"Design of reinforced concrete water storage tank case study BUSASAMANA Sector in NYANZA District"** is a recorded of the original work done by IRADUKUNDA Franck. In partial fulfillment of the requirement for the award of advanced diploma in civil engineering department, optionof construction technology in ULK POLYTECHNIC during academic year 2023-2024

SUPERVISOR	SIGNATURE
Eng MUTIJIMA Jeanine	…………………………

DATE………/.............. /2024

DEDICATION

We dedicated this book to our Almighty God who protect us during the whole days of our studies.

We dedicate also this book to our lovely parents, our classmates, To ULK staff and to anyone who contributed in the completion of this book especially Eng. MUTIJIMA Jeanine my supervisor of this This Practical Report.

ACKNOWLWDGEMENTS

The present study is the product of the efforts prepared since the beginning of advanced diploma program at ULK Polytechnic.

Firstly, I thank my almighty GOD for this great and overall care they have provided to me throughout my life and studies. We would like to acknowledge the parental care assistance, advises financial and moral supports our parents and our family members have given to us.

We would like to take this opportunity to express our appreciation to my supervisor

Eng. MUTIJIMA Jeanine for these constructive suggestions and encouragement our honor also goes towards the ministry of infrastructure in Rwanda. Water and sanitation corporation (WASAC), the concerned respondents in BUSASAMANA Sector to have provided us with the information and the documentation necessary for the realization of the present research work. Finally, we, send thanks to our lovely classmates, who helped us during our academic life in their collaboration, we, humbly to say thank you.

ABSTRACT

This final year is a result of deep study on project called **"Design of reinforced concrete water storage tank"** located in BUSASAMANA Sector/ NYANZA District. Storage tanks are containers that hold liquids, compressed gases (gas tank) or mediums used for the short or long- term storage. Most storage tanks are designed according to American petroleum institute API-650 specification these tanks can have different sizes ranging from 2 to 60m diameter or more. The aim of this project is to determine the requirement of water storage tank, to describe water storage tank capacity to make economic analysis for water storage tank and to design a water storage tank, according to that aim the old water storage tank in BUSASAMANA Sector will be reduced or eliminated. This sector characterized by high density of low water storage tank ac- companied of bad odor. The design of reinforced concrete water storage tank will be the solution to the problem of water shortage in Busasamana Sector.

This report is subdivided into five chapters. Where the first chapter is the general introduction, the second chapter is Literature review of reinforced concrete water storage tank, the third chapter will show research methodology used during data collection, their analysis and discussion the fourth chapter will shows the result and discussion finding then last chapter is conclusion and recommendation.

The Various survey was conducted to determine information about reinforced concrete water storage tank the methodology used ware interview to the people and other person who has skills about design of reinforced concrete water storage tank. Other survey was conducted to deter- mine information

Is observation to the site as engineering's students. The information obtained were analyzed and based on discussion made result was that there is a need of reinforced concrete storage tankin Busasamana Sector because people travelled between 1-2km and spend two hours going to seekwater due to poor access and quality to drinking water and also to in order to seek their water they spent 70frw of twenty liters of water. Then the answer of this problem found in this focused there is need of 400m^3 of water storage tank in order to get enough water demand/day the building in BUSASAMANA Sector General.

LIST OF SYMBOLS AND ABBREVIATIONS

@: Spacing (between two steel bars

∫max: Maximum spacing of cracks

As min: The minimum required area of the reinforcement

As: Area of the tensile reinforcement

Asv: Area of the nominal links or stirrups

C: The concrete cover

d: The effective depth of the member WASAC: Water and sanitation corporation

Eng: Engineer

Ec: young modulus of elasticity of concrete

Es: young modulus of elasticity of steel reinforcement

fcu: The compressive strength of the concrete fy: The characteristic strength of the stirrups Gk: The dead load

h: The overall depth of the member

Qk: The live load

RCC: Reinforced Cement concrete

UPI: ULK Polytechnic Institute

WHO: World Health Organization

X: depth of neutral axis

Φ: The diameter of the reinforcement

β**sx**: Short span coeffient for all values of Ly/Lx Asc: Area of the compression reinforcement BS: British Standard

β**sy**: Long span coefficient for all values of Ly/Lx

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CHAPTER ONE GENERAL INTRODUCTION

1.0. Introduction

A water storage tank is a container for storage of water for domestic and industrial uses. Water storage tanks are available in many shapes and sizes. They can be vertical, horizontal, underground and potable; Water tanks made of reinforced concrete are designed to hold water. Based on (BS 8110-1, 1997), the reinforced concrete water tank's design the layout is determined by where the water tanks are located—underground, on the ground, or high.

, i.e., overhead, on ground or underground water tanks. But tank we designing will be located over the ground, and it will be made in reinforced concrete.

Tanks can be constructed in a variety of shapes, the most common being round and rectangular. Steel or reinforced concrete may be used to make the tanks. Usually, columns are used to raise the overhead tanks, also known as elevated tanks, from the rooftop. In the alternative the foundation is where the subterranean tanks are resting.

1.2. Back ground of study

The availability of sufficient water drinking water supply is a principal need in our daily life. It has been a matter of concern since the beginning of civilization during the first century the 12millions of in habitant of ancient Rome enjoyed over 900millions liters/ day delivered by a system of pipe over 100km long. (**Encyclopedia Britannia fourteenth edition)**

Archeological observation demonstrates that all other early civilization regarded, organized water supply as essential requisite of living as well. Nearly two thousand years later one expects that the situation only improved having in mind development of science and technology still quite many regions in the world live under water supply condition. Water supply and sanitation issues are therefore prevalent in sub-Saharan Africa still to the conflict and political instability, war, high rates of population growth, and low priority given to water supply and sanitation. Is based on data given by World Health Organization (WHO) consequently, much of African rural areas is confronted with inadequate water supply by the entire developing countries. The country has been left without sufficient, reliable or clean water-in many regions owning to a lack of infrastructure, deforestation and erosion.

The daily completion is not more than 20 liters per person per day.

In this way, there is need to investigate considerations for the design of water storage tank as a-strategy for water supply to domestic use in rural areas. This study will find sustainable means-for access to water supply in BUSASAMANA Sector/ NYANZA district.

Figure 1.1.Source of drink water for some people of BUSASAMANA Sector

1.2 Problem statement

The growth problem which this study concerns turns around consists in knowing how designing of water storage tank in order to improve water supply for domestic users in the area of Busasamana Sector, the sector of Nyanza district which has the greatest number of families without access to water. In this way of designing and building water storage tanks is becoming an important option for supply rural habitants in Busasamana Sector for the purpose of resolve the problem concerning to the water shortages. This study is undertaken provide more information related to water storage tanks to supplement water supplies systems by the water sanitation cooperation (WASAC) The study tries to suitable and technical considerations to the design and supply needed to resolve the problem. In light to the above consideration, the study aims at examining consideration for design of water storage tank in Busasamana Sector in order to resolve the problem of water shortage in this area.

1.3 Objectives

In order to collect relevant information for this study, both general and specific objectives will guide the research process. This study will provide the way of considerations for the design of water storage tank at rural facilities, gave a typical design analysis for tanks and provides the procedures and capacity requirements of the tank to be followed in selecting sites for such works.

1.3.1 Main objectives

The main objective of this project is to design of water storage tank for water service provision in Busasamana Sector.

1.3.2 Specific objectives

Specifically, this study is guided by the following specific objectives

- To determine Water demand in Busasamana Sector
- To determine Quantities or Volume of required water storage tank
- To determine Architectural and structural drawings for proposed project
- To provide safe drinkable water after storing for a long time
- To determine forecasting future population in Busasamana Sector

It is interest for us because it shows that water storage tanks project is a way of supplying water-to rural people especially in Busasamana Sector. Academically it will help the students to know their country try and it will provide the effectiveness of how to resolve the problem of water shortage.

It is the intention that some of the results of this research be used to improve the water supply and quality water in BUSASAMANA sector by designing and constructing a water storage tank. Once this water storage tank will be constructed it will help people to obtain water to be used for domestic activities, also the people will be free from dirty.

In addition, this project will allow researchers to be familiar with planning and Design of water storage tank.

1.4. Research questionnaires

1.4.1 Current water supply situation:

- What is the current water availability per household in Busasamana Sector?
- How many families lack access to clean water?
- What are the existing water sources and their reliability?

1.4.2 Water demand assessment:

- What is the estimated daily water requirement per person/household?
- How does water demand vary seasonally?
- What are the projected population growth rates and future water needs?

1.4.3 Geographical and environmental factors:

- What are the topographical features of the area?
- What are the soil conditions and geological characteristics?

- What are the local climate patterns, including rainfall and evaporation rates?

1.4.5 Technical design considerations:

- What is the optimal capacity for the water storage tanks?
- What materials are most suitable for construction (e.g., reinforced concrete, steel)?
- What are the structural design requirements to ensure durability and safety?

1.4.6 Water quality and treatment:

- What is the quality of the water to be stored?
- What treatment methods, if any, are required?
- How can water quality be maintained during storage?

1.4.7 Distribution system:

- How will water be distributed from the storage tanks to households?
- What pumping systems or gravity-fed options are feasible?
- What is the required pipeline network?

1.4.8 Cost and economic factors:

- What is the estimated cost of designing and constructing the water storage tanks?
- What are the ongoing maintenance and operational costs?
- How will the project be funded?

1.4.9 Community engagement:

- How can the local community be involved in the design and implementation process?
- What are the community's preferences and concerns regarding water storage solutions?

1.4.10 Integration with existing systems:

- How will the new water storage tanks integrate with existing WASAC infrastructure?
- What improvements to the current water supply system are needed?
- Sustainability and long-term planning:
- How can the design ensure long-term sustainability of the water supply?
- What measures can be implemented for water conservation and efficient use?

1.4.11 Environmental impact:

- What potential environmental impacts might result from the construction and operation of the water storage tanks?

- How can these impacts be mitigated?

1.4.12 Regulatory compliance:

- What local and national regulations must be adhered to in the design and construction process?
- What permits or approvals are required?

1.5. Scope and limitation of project

This research was conducted exclusively in Busasamana Sector. The project entitled designing of ground water tank will cover. Then this project is scope for determination of water demand and number of people which the tank will be designed for, design of adequate water storage tank and cost estimation. But those will be eliminated. The determination of detailed geotechnical study and topographic survey data, detailed structure design, architectural drawings, detailed water supply of this project, earthquake calculations.

1.6. Significance of study

1.6.1 Personnel significance

This project will provide valuable hands-on experience in the design of reinforced concrete water storage tanks.. The skills and knowledge gained through this study will be directly applicable to future career opportunities in civil engineering, particularly in the water resources and structural design sectors.

1.6.2 Academic significance

This project will be considered as reference document for students of Civil engineering department who may wish to read about design of reinforced water storage tank.

1.6.3 Social significance

The design and construction of efficient water storage tanks have significant social implications:

- **Improved water security:** Well-designed tanks ensure a stable water supply for communities, reducing the impact of water shortages and improving overall quality of life.
- **Public health:** Properly constructed tanks help maintain water quality, reducing the risk of waterborne diseases and contributing to better public health outcomes.

- **Economic benefits:** Efficient water storage systems can lead to reduced water costs for communities and businesses, promoting economic growth and development.
- **Sustainability**: Optimized tank designs can contribute to more sustainable water management practices, helping communities adapt to changing climate conditions and population growth.
- **Infrastructure resilience:** Properly designed tanks can better withstand natural disasters, ensuring continued water supply during emergencies.

1.7 Methodologies

Methodology refers to the principles that are used when studying a particular kind of work. In this project concern with design of Reinforced water storage tank we will prefer to use: Observation supported by interview. Also, in this methodology, different steps were taken. These include:

- Review of literatures, that is consultation of the published documents on the design of-reinforced concrete water storage tank such books and internet.
- Working with our supervisor for more guidance on this project. Site and ground investigation. Documentation from the library and searched on the internet to learn and well understand all recommendations used in design of reinforced concrete water storage tank.

1.8: organization of study

Organization of the Study: Design of Reinforced Concrete Water Storage Tank

Chapter 1: General Introduction

Background of water storage tanks and their importance

Statement of the problem (e.g., need for efficient and durable water storage solutions)

Objectives of the project (e.g., designing a reinforced concrete water storage tank)

Delimitation of research (scope and limitations of the study)

Summary of methodology for tank design and analysis

Chapter 2: Literature Review

Review of reinforced concrete properties and behavior

Water storage tank design principles and standards

Structural analysis concepts for tank design

Previous studies on reinforced concrete water tanks

Environmental and safety considerations in tank design

Chapter 3: Methods and Techniques

Design methodology for the reinforced concrete water tank

Materials selection and specifications

Structural analysis techniques used (e.g., finite element analysis)

Design considerations (e.g., capacity, shape, reinforcement details)

Study area or case study location (if applicable)

Chapter 4: Results and Discussions

Structural analysis results of the designed tank

Detailed design specifications (dimensions, reinforcement layout, etc.)

Discussion of design choices and their implications

Comparison with standard practices or alternative designs

Performance evaluation of the proposed design

Chapter 5: Conclusion and Recommendations

Summary of key findings from the tank design process

Conclusions on the efficacy and feasibility of the design

Significance of the study in the context of water storage infrastructure

Recommendations for implementation and future research

Potential improvements or variations in the design

CHAPTER TWO: LITERATURE REVIEW

2.0. INTRODUCTION

A water tank is used to store water to facilitate the daily requirements of habitats. Typesof water tank based on placing and shape. Compared to other forms, circular tanks require less surface area to achieve a given storage capacity. Therefore, less material is needed for a circular water tank than for other shapes.

However, compared to other forms, the form work for a circular tank is far more intricate and costly.

Different forms. Water tanks that are square or rectangular are typically utilized beneath the ground or atop.

The earth. For raised tanks, circular tanks are the best option.

And also, a structure intended to hold liquids needs to meet the same standards as regular structures in terms of strength, durability, and lack of severe deflection or cracking. In additionally, it needs to be made such that the liquid cannot seep through or leak.

The construction made of concrete.

In the design of normal building structures, the most critical as part of the design is to ensure that the structure retains its stability under the imposed loads. When designing a structure to hold liquids, it is typical to discover that, if the structure is reinforced and sized to hold the liquid in place without leaking, then the strength is more than adequate.

2.1. Main reason of design

The main reason of this project of Reinforced concrete water storage tank is to ensure that the structure will perform satisfactorily during its design life. Specifically, the de- signer must check that the structure is capable of carrying the loads safely and economically. For the structure to be safe, it must be able to resist the worst loading conditions.For the structure to remain functional, strong, and visually pleasing under typical operating conditions, there must be a reasonable amount of deformation and breaking during the expected design life. The structure should be economical with regard to both construction and maintenance cost.

2.1.1 Code used for design

Structural design is often governed by a Code of Practice appropriate to the location of the structure. Whilst the basic design objectives are similar in each Impermeability code, the specified stresses and factors of safety may. The British standard is being used to design the structural elements and the loading from the building are listed below:

- BS 648:1964: Weights of building materials contain.
- British Standard Code of Practice BS 8007: 1987 Design of concrete structures for retaining aqueous liquids
- BS 8110 part one (1): Structural use of concrete contain code of practice for design
- BS 8110 part three (3): 1985, Structural use of concrete contain Design charts for rectangular columns, doubly reinforced beams, and single-reinforced beams in general, our design will refer to BS8110:1985: Concrete's Use in Structure

All these codes include material specifications, joint details and design procedures to limit cracking. British Standard Code of Practice BS 8007: 1987 is a revised version of BS 5337: 1976, which itself derives from BSCP 2007.

2.1.2Design methods

The design of water retaining structures may be carried out using either (1) Limit state design, or (2) an elastic design. A limit state design would be based on both the ultimate and serviceability limit state, using the methods described in previous units. As the restraint of cracking is of prime importance with these structures, the simplified rules for minimum steel areas and maximum spacing would no longer be adequate.

The elastic design is the traditional method which will probably continue to be used for many structures. It is relatively simple and easy to apply. Possibly it will be used in conjunction with limit state methods when there are special circumstances, such as when stability, so that the critical loading patterns for the ultimate limit state should be considered. Even though a structure has been designed by the elastic method it may still be necessary to calculate the possiblemovement crack widths.

2.1.3 Limits state design and structure analysis

The application of limit state techniques to water retaining structures is relatively new and the recommendations of BS 8110 are used subject: to modifications contained in BS 5337. For the ultimate limit state, the procedures followed are exactly the same for any other reinforced structure. The partial factor of safety on imposed loading due contained liquid could be taken as 1.4 for strength calculations to reflect the degree of ac- curacy with which hydrostatic loading may be predicted. Calculations for the analysis of the structure subject to the most severe load combinations will proceed in usual way but the reinforcement characteristic strengths should not be taken to exceed 425 N/mm2. The two types of limit state are the following:

- The ultimate limit state (ULS) and
- The serviceability limit state (SLS). (W.H Mosley, J.H. Bungey, 1987).

2.1.4 Ultimate limit state

The ultimate limit state (ULS) is the design for the safety of a structure and its users by limiting the stress that materials experience ULS must be met as a precondition in order to meet technical requirements for strength and stability under design loads. (Cormack, 2008).
If the computed values for all factored bending, shear, tensile, and compressive stresses are lower than resistances, a structure will meet the requirements of the ULS. Dependability and safety can be presumptive given that this requirement is met, as the structure will operate in the same manner under constant loadings.

The strength of the structure should be sufficient to with-stand the design loads, taking into account of the possibility of overturning or buckling(W.H Mosley, J.H. Bungey, 1987) and (BS 8110 part 1, 1997).

2.1.5. Serviceability limits state

The serviceability limit state (SLS) is the design to ensure a structure is comfortable and useable. This includes vibrations and deflections (movements), as well as cracking and durability. These are the non-strength-based problems that could somehow make the structure unfit for its intended use, like making occupants uncomfortable in everyday situations.
Generally speaking, SLS criteria are less strict than strength-based
limit states since there is no doubt about the structure's safety.
When regularly loaded, a structure must continue to perform as intended in order to
meet the SLS requirement.
(McCormack)

2.1.6 The most significant serviceability limit states are:

Deflection: Any aspect of the structure's efficiency or appearance cannot be negatively impacted by deflections.

Cracking: Spelling errors and localized cracking damage shall not compromise the look, functionality, or longevity of the building.

Durability: This needs to be taken into account with the structure's anticipated lifespan and its circumstances of exposure.

Excessive vibration- which may cause discomfort or alarm as well as damage.

Fatigue-must is considered if cyclic loading is likely.

2.2 Tank

As most of civil engineering works, Tank should be founded on firm foundation if they must beconstructed above ground. In case where underground reservoir or tanks are preferred due to head problem for gravity flow the effect of tree roots and maximum water table fluctuation should have been serious consideration on the structure stability. (Gould, 1990)

Tanks can be constructed in a variety of shapes, the most common being round and rectangular. The tanks can also be constructed out of steel or reinforced concrete.

2.2.1. Types of RCC water tank based on their location and shapes

2.2.1.1 Based on water tank location

underground storage tanks Tank laying down on the ground Above-ground tanks

2.2.1.2. Types of RCC water tanks based on their forms and locations

based on the location of the subsurface storage tanks for water tanks on the ground, lying down Above-ground reservoirs.

- Considering the structure of the water tank.
- Shape of a rectangle round form round form.
- Circular container with a conical bottom.

2.2.1.3. Component of a water storage tanks

The water storage tanks are designed as it must be composed by different parts. These parts each have its own responsibilities. It leads to the appropriateness of water in distribution. Its components are follows:

- **Inlet and Outlet:** The inlet is used to supply water to the tank while the outlet lets the water out for distribution. In order to allow you to store the most water possible, we designed the inflow at the highest level of the tank.

- **The outflow** is positioned at the bottom of the tank to assist you use as much water as possible by facilitating water circulation.

  Maintaining the residual chlorine content in the water requires water circulation. In order to prevent contaminants from flowing out with the water, we position the outlets 4 to 6 inches above the tank's bottom.
- **Drain:** The tank may be emptied as needed thanks to the drain at the bottom that we supply. In order to remove deposits and sediments, you might need to empty the tank.
- **Overflow Pipe:** The tank has overflow pipes at the top to make sure it doesn't fill up to capacity. Overfilling a tank can cause harm to its components and increase the risk of a rupture. Additionally, overflow pipelines provide freeboard to keep the tank's required air gap. Overflow pipes are often positioned at the same level as inlets.
- **Vent:** Located on top, vent pipes aid in releasing air pressure during tank filling. We make sure that the vent pipes are not able to let any debris or pollutants into the water.
- **Water Level Indicator:** To determine the water level in the tank, we often use dipsticks, which are graduated rods.
- **Top Cover:** The top of the tank has an opening or utility hole for cleaning, maintaining, and inspecting the tank. The cover has a lid and is large enough to allow someone to enter for upkeep and cleaning.
- **Sump:** For draining, there are sump pumps at the tank's base. In the event that you want to employ submersible pumps for subterranean or above-ground water tanks, you will also require extra sump pumps. Depending on your needs and the situation, we could incorporate extra elements into the design of your tank. For above tanks, for instance, we can offer features like protection rails, a staircase, and more. Located on top, vent pipes aid in releasing air pressure during tank filling. We make sure that the vent pipes are not able to let any debris or pollutants into the water.
- **Water Level Indicator:** To determine the water level in the tank, we often use dipsticks, which are graduated rods.
- **Top Cover:** The top of the tank has an opening or utility hole for cleaning, maintaining, and inspecting the tank. The cover has a lid and is large enough to allow someone to enter for upkeep and cleaning.

2.2.1.4. Design of Circular Tanks resting on ground with rigid base

The bottom portion of the wall will bend like a cantilever, and the higher part will have hoop tension due to fixity at the base of the wall. Shallow tanks with large diameters have relatively tiny hoop stresses, causing the wall to behave more like a cantilever. The hoop action predominates in deep tanks with small diameters and the cantilever action is minimal due to fixity at the base.

It is challenging to precisely analyze the tank to identify the wall section where cantilever action predominates and the region where hoop tension is predominating. Simplified analytical techniques include:

I. Reissner's approach

II. The Carpenter's Simplified Approach

III. Approximation technique

IV. The method of BS code

the typical base slab thickness ranges from 150 to 250 mm, with the smallest amount of steel placed at the top and bottom of the slab.

2.2.1.5 Design load acting on the structure

The types of loads acting on structures for Vertical loads, horizontal loads, and longitudinal loads are the general categories into which buildings and other structures fall. There are three types of vertical loads: impact, live, and dead. Earthquake and wind loads are included in the horizontal loads. When designing bridges, gantry girders, and other structures, the longitudinal loads—that is, the tractive and braking forces—are taken into account but also in our project we will consider the Service loads because are actual loads that the structure is designed to carry. The characteristic loads used in the design are the flowing: Dead load, imposed load and wind load which are providedby (BS 8110 Part1, 1997)

2.3 Types of loads

2.3.1 Dead load (DL)

Dead load is the initial vertical load taken into account. Dead loads are loads that are transferred to a structure during the course of its life and are either permanent or immobile. The main causes of dead load are the weight of various materials, permanent equipment, partition walls, and structural components. It mostly consists of the weight of columns, walls, beams, and roofs, among other things. Which are otherwise the building's permanent components. The unit weights of some common materials are specified by: (BS 63399 Pat 1, 1996); the dead loads of each structure are determined by multiplying the volume of each section by the unit weight.

2.3.2 Imposed load or live load (LL)

Impeded loads, also known as living loads, are the second vertical load taken into account during the design of a building. Live loads can be in motion or moveable, but they never accelerate or impact. These loads—which include the weights of moveable partitions, furniture, and other items—are presumed to be generated by the building's intended use or occupancy.

Live loads are always fluctuating. The minimum assumed live load values are determined by the building's intended use. The source of these live loads is (BS 6399 Part 1, 1996)

2.3.4 Winds loads

The movement of air in relation to the earth causes wind load (WL), which is essentially a horizontal load. Depending on the location, height, shape, and dimensions of the buildings, wind load must be taken into account throughout the structural design process (BS 6399 Part 1, 1996).

2.3.5 Load Combinations for the Ultimate State

Various combinations of 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. The partial factors of safety specified by BS 8110. Also are in table 2.2 of Partial factors of safety for loadings from (W.H Mosley, J.H. Bungey, 1987)

For the ultimate limit state, the loading combinations to be considered are as follows:
Dead and imposed load: 1.4 Qk + 1.6 Gk
Dead and wind load: 1.4Qk + 1.0Wk
Dead imposed and wind load: 1.4Qk + 1.6Gk + 1.0Wk

2.4 Water

Water or planet earth exist of three aggregate vapor, liquid and solid (snow) the total volume of water on the planet estimated at 1408.7X 10^6 m3 is the same nowadays as it was in the time it emerged or few billion years ago. Water is distributed in several ponds with different size and type, during the earth history only distribution of water among the pond was changing depending on the Temperature.

Table 1.2.pond of water on the earth

Pool	Volume (10^6)	Total %
Ocean	1370	97.25
Ice	29	2.05
Ground water	9.5	0.68
Lake	0.125	0.01
Soil	0.065	0.005
Atmosphere	0.013	0.001
River	0.0017	0.001
TOTAL	1408.7	100

Water has more importance to all citizens and it should be supplied to all people in order to be comfortable in a sale way. Water also 1s important in our life because it has been a matter it concerns since the beginning of civilization in our environment. Also, water is used for many activities such as cooking, drinking and washing, construction for making mortar. (Mayer, 2016)

Figure 2.2.Pond and well located in BUSASAMANA Sector

The degradation of the natural resources, the increase in population and rapid urbanization causes water to be loss. In this way, the sustainability for using water become a strategic importance in both the developing of people and developed nations (WASAC, 2016).

The basic source of all water on the earth is the rainfall. Theoretically considerations for the design of a water storage tank towards the Distribution system will use design and plan standardized theories: These are:

A. Theory about the determinations of capacity requirements for water storage tanks
B. Theory about the capacity of water storage tanks
C. Theory about the design of a water storage thanks based on demand-supply and design calculations.

Therefore, supply, demand and economics considerations form the baseline theory concerning standard design criteria, construction materials, maintenance and repair and all depends on the kind of constructed tanks.

Safe bearing capacity

The ability of soil to withstand loads applied to it is known as bearing capacity. The greatest average contact pressure between the foundation and the soil that prevents the soil from shearing is known as the bearing capacity of the soil. Allowable bearing capacity is calculated by dividing the ultimate bearing capacity by a safety factor. Ultimate bearing capacity is the highest theoretical pressure that can be supported without failure. The varieties of soil affect these factors. (J.H. Bungey and W.H. Mosley, 1987)

Table 2.2.Typical allowable bearing values

Rock or soil	Typical bearing value (KN/m2)
Massive igneous bedrock	10000
Sandstone	2000 to 4000
Shales and mudstone	600 to 2000
Gravel, sand and gravel, compact	600
Medium dense sand	100 to 300
Loose fine sand	less than 100
Hard clay	300 to 600
Medium clay	100 to 300
Soft clay	less than 75

- **Loading**

  Liquid retention strictures' field covers must to be engineered to withstand gravity loads, including the weight of the slab, roof, ground cover for any living loads, and mechanical equipment. In the event that internal gas pressure is applied to the liquid retaining structure, they should also be built for upward load. When planning roofs, one should account for a superficial load that is adequate to guarantee safety in light of the uneven intensity of loading that arises during the placement of the ground cover. Under these temporary circumstances, the engineer should designate a loading that must not be exceeded. When designing the roof, consideration for the transient state of Even if the end state may see a little and equally distributed load, certain spans are loaded and others are emptied.

- **Water tightness.** When using tanks to store water for household use, the roof needs to be sealed to keep out water. This can be accomplished in a few ways: by keeping the tank's overall stresses to a minimum; by using a watertight membrane covering; or by creating slopes that allow for proper drainage.

i **Floor of water storage tanks resting on supports**

The floor slab must be constructed for bending moments resulting from water load and self-weight in structures if the tank is supported by walls or other supports. (2016, Concrete)

1. It needs to be built to withstand bending moments brought on by water and dead loads.
2. Extra care must be taken when designing the multi-cell water tank's floor.
3. Lastly, floor design must take into account the moment at the junction together with other transferred loads when walls and floors are attached firmly.

ii. Floors of tanks resting on ground

When building a tank on the ground floor, concrete may be used with minimal reinforcing as long as the ground can support the weight without experiencing any noticeable subsidence in any area and the concrete floor is made of panels with no more than 4.5 meters of side length.

iii. Wall of Reinforced water storage tank

In planar walls, both vertical and horizontal bending moments oppose the liquid pressure. The percentage of pressure resisted by bending moments in the horizontal and vertical planes should be estimated. In addition to the tension arising from horizontal bending moments, there should also be added the direct horizontal tension resulting from the direct draw of water pressure on the end walls.

2. 5 Pressure on wall

The liquid pressure must be increased by the gas pressure that is created by a fixed or floated tank cover. Earth pressure must be taken into consideration when designing walls for water tanks that are built on the ground or with the earth pressed up against them. Additionally, the gas pressure that develops above the liquid surface in a water storage tank with floating covers must be added to the liquid pressure.

2.5.1 Foundation of reinforced water storage tank

Bearing capacity of the subsoil, or the soil's ability to hold the loads applied to the earth, was required during the design of the reinforced concrete water storage tank project. The greatest average contact pressure between the foundation and the soil that prevents the soil from shearing is known as the bearing capacity of the soil.

iv. Ultimate bearing capacity is the theoretical.

Maximum pressure that a bearing can withstand before failing; allowed bearing pressure is calculated by dividing the maximum bearing capacity by a safety factor.

Large settlements beneath loaded foundations without shear failure can occasionally happen on soft soil locations; in these situations, the maximum permissible settlement determines the allowable bearing capacity. Terzaghi's Bearing Capacity Theory is one of several theories that can be used to determine bearing capacity. In 1943, Terzaghi created a technique for figuring the bearing capacity for the typical shear failure scenario.

The equations are given below. For square foundation: when cohesion is equal to 0 $qf= 1.3cNc+qNq+0.4\gamma BN\gamma$

For circular foundation: when c=0

$qf= 1.3cNc +qNq+0.3\gamma BN\gamma$

Rectangular foundation

$qf=cNc +qNq+1/2\gamma BN\gamma$

in this design of reinforced concrete water storage tank, I prefer to use circular foundation because this water storage tank is circular form.

2.5.1. Provision of Movement joints.

If the roof and walls are monolithic (an unchanging structure), it is crucial to make sure that the movement joints in the roof match those in the walls to prevent the potential of cracking. Still, it. A sliding joint is used to provide space for movement between the wall and the ceiling; joint correspondence is not very crucial.

2.5.2. Joints in liquid retaining structures

1. The joint of contraction. It is a movement junction that is purposefully discontinuous and does not have an initial space between the concrete on either side. This joint's function is to allow for concrete contraction.
2. Expansion Joint.
It is a junction designed to support the structure's expansion or contraction and has a complete discontinuity in both the reinforcing steel and the concrete.
3. Sliding Joint. It's a joint with a unique design that allows for maximum movement in the joint's plane and total discontinuity in the concrete and reinforcement.

2.6. Reinforced concrete materials

The composite material known as reinforced concrete is made up of steel rods inserted in a hardened Steel resists tensile stresses, while concrete, with the help of steel, carries the compressive force. By itself, concrete is a composite material. Fine and coarse aggregate, as well as cement, make up the dry mix. When using clean water to make concrete, it should be mixed with cement to initiate the hydration of the cement paste and with aggregate to fill in the spaces and give the mixture workability. The concrete solidifies into a hard mass as it sets. Concrete is made workable by water, which enables easy mixing and placement of the concrete at the desired location. The more water there is, the more feasible it is. But too much water weakens the effect.

2.7. Permissible stress on concrete Permissible stress for resistance of cracking

The concrete used for water tanks must be leak-free. This can be accomplished by using concrete that is at least M-20 graded and by placing concrete close to the water's edge in a way that prevents cracking. In order to prevent cracks in concrete at the water face, the thickness of the water tank wall must be built to reduce the amount of stress on the concrete below the values specified in BS 8110 Part 2.

These allowable bending stresses also apply to the face that is not in touch with the liquid in members that are less than 225 mm thick and in contact with it on one side.

Calculation of crack widths due to fracture

Depending on the member's degree of exposure, the limit state of cracking is achieved by making sure the maximum computed surface width of cracks does not exceed the designated value. The process listed below must be followed in order to measure the surface crack width:

Determine the service bending moment (a).

(a) Using elastic theory, determine the neutral axis, lever arm, and steel stress depth.

(c) Determine the surface strain taking consideration of the concrete's stiffening effect.

(d) Determine how wide the crack is.

Maximum cracks cannot be larger than 0.2 mm. The maximum service bending moment is determined using characteristic loads.

2.8 Properties of materials

Any civil engineering project needs to consider material attributes during both the design and construction stages. Roads, railroads, bridges, dams, culverts, drainage and water distribution systems, airports, and big industrial projects are examples of civil engineering projects. The following criteria must be taken into consideration while determining the best structural shape and materials: material cost, physical characteristics, durability, material availability, ease of building, and speed.

2.8.1 Deformation of metal

When there is an applied force on the work as a result of compression, deformation occurs, and tension results from a change in temperature.

2.8.2 Cement

Typical the most often utilized type of cement is Portland cement. It is made of iron oxide, silica, alumina, and lime as primary components. In a rotating kiln, these ingredients are ground, mixed, and burned in the proper ratios. To make cement, the clinker is cooled, combined with gypsum, and ground into a fine powder. The primary chemical constituents of cement are aluminates and calcium silicates. Chemical reactions take place when water is introduced to cement and the ingredients are combined to create cement paste. As a result, the mixture sets and gets stiffer over time.

In addition to joining aggregates and surrounding surfaces like stone and brick, cement also hydrates and binds when water is added. Generally speaking, stronger mixes need more cement and are richer. After 30 minutes, setting time begins, and it lasts for 6 hours.

2.8.3. Coarse aggregate consists of crushed stones.

The stones should be of igneous origin and the grade should be good. They ought to be firm, angular, crisp, and clean. They stop cement from shrinking and provide the concrete bulk. And it's made out of crushed rock or gravel that is at least 5 mm in size.

2.8.4. Fine aggregate consists of river sand.

It keeps cement from shrinking. It becomes more mobile when encased in cement, filling the spaces between the coarse aggregates and causing the components to bind. It gives concrete more density since it fills in the spaces and contains sand that is smaller than 5 mm. The variable density can be used to build concrete with a wide range of unit weights; lightweight, normal-weight, and heavyweight aggregates are the most frequent categories of aggregates based on bulk specific gravity. Particularly, the many features included in both light-weight and heavy weight aggregates are discussed in this section. (PERTERSEN, 1989)

2.8.5 Lightweight aggregate

Aggregates classified as lightweight typically have a bulk density of less than 1120 kg/m3, are highly variable, and have an angular and irregular shape. Additionally, because of their high porosities, they have a significant capacity to absorb water from the mixture.

2.8.6. Heavyweight Aggregates

Heavyweight concretes with unit weights ranging from roughly 2900 to 6000 kg/m3 are made from heavyweight aggregates.

2.8.7 Normal weight Aggregates

Most common aggregates are sand, Gravel, and Crushed stone which are used to produce normal-weight concrete of 2200 to 2400 kg/m^3. These aggregates used to produce normal weight concrete for ordinary use or application.

Figure 3.2.Gravel and Sand

2.8.8. Reinforcement

The reinforcement is typically passively implanted in the concrete before it hardens and is typically, though not always, steel reinforcing bars, or rebar. Generally speaking, reinforcing schemes are made to withstand tensile stresses in certain concrete zones that could otherwise result in undesirable cracking and/or structural collapse. In order to enhance the final structure's behavior under working loads, modern reinforced concrete can use a variety of steel reinforcement. It can also be permanently stressed (in).

Hot rolled mild steel bars have yield strength (fy) of 250 N/mm2, whereas hot rolled or cold worked high yield steel bars have a yield strength (ty) of 460 Nmm2. Reinforcing bars are made in two categories. Steel fabric, which has yield strength of 460 N/mm2, is created by welding cold-drawn steel wires into a mesh.

2.9. Permissible stress in steel

The stress in steel must not be allowed to exceed the following values under different positions to prevent cracking of concrete.

When steel is placed near the face of the members in contact with liquid 115 N/mm^2 for mild steel Bars and 150 N/mm^2 for high strength deformed bars.

If steel is placed on the face away from the liquid for members 225 mm or more in thickness, then permissible stress in steel shall be 125 N/mm^2 for mild steel bars and 190 N/mm^2 for high strength deformed bars.

When steel is placed on face away from liquid for members less than 225 mm in thick-ness same as earlier.

2.9.1Steel reinforcement formulas

K= $\frac{M}{Fcu\,BD^2}$; if K>0.156 Compression reinforcements are required and K<0.156 Compression reinforcements are not required Z = d [0.5 +] where 0.775d < Z < 0.95d

And the transverse reinforcement is calculated from this formula: As =$\frac{M}{87FYZ}$; as known asmain steel bars. 0.13bh ⁄ 100 = the minimum area of reinforcement for high yield steel.

2.9.2 Shear reinforcement formulas

V=$\frac{V}{BD}$<the maximum allowable shear stress= Min√0.87 or r 5$N/mm^2$and $\frac{100AS}{BD}$ for calculation **by** (BS 8110 part 1, 1997) To find shear reinforcement table 3.16 in BS8110-1:1997 is used and closes which areused in shear design are: 3.4.5.8, 3.4.5.9 and 3.4.5.10 in BS8110-1:1997.

2.9.3. Design of reinforcement bars

Assume diameter of main steel and secondary steel provide effective depth (d) on both sides. Moment of resistance (Mu) =0.156 $fcubd^2$ where K=$\frac{M}{Fcubd^2}$, Z=d [0.5+ (√0.25 –K/0.9)] and

As= ≥As min=0.13%bh . if As < As min provide reinforcement corresponding

To as min provided by BS8110-1:1997 Reinforcement areas (clause 3.12.5, BS 8110).

The area of tension reinforcement, as, should not be less than the following limits: As ≥ 0.24%Ac when fy = 250 N/mm2, As ≥ 0.13%Ac when fy = 500 N/mm2, Where Ac is the total area of concrete.

2.9.4. Design of slab

Slab classified into two types such as two-way slab and one-way slab The slab is called two ways when $\frac{Ly}{Lx}$<2

Steps of designing two-way slab provided by BS 8110.

1. Design Moments

The following lists the maximum design moments per unit width for rectangular slabs with longer side Ly and shorter side Lx:

Msx = Bsx×n×lx2 is the shorter spanning side, while Msy = Bsy × n × lx2 is the longer spanning side. In other words, finding reinforcement after obtaining a moment on both the longer and shorter sides is similar to one-way slabs, but there are two methods to deliver reinforcement along the shorter and longer directions. A source of the coefficients Bsx and Bsy is BS 8110-1:1997. close: Table 3.14, 3.5.3.7

2. Deflection check

The deflection is found in the mid-span and is done by using bending moment. $\frac{Span}{Effective\ depth}$

1/d = 26 Actual

M.F= 0.55+

M. F= 0.55 +

M.F= 1.79

Fs= $\frac{5}{8}$ fy $\frac{Area\ Required}{Area\ Provided}$ and $\frac{Permissible\ span}{Effective\ Depth}$= basic ratio × MF

If M.F > 2 take 2 to calculate permissible ratio = (1/d) * 2 or M.F and if the permissible ratio is greater than the real ratio, the section of the slab is enough and adequate hence there is no deflection.

Crack check: In order to prevent slab cracks, the code of practice also specifies that there may be a space bigger than three dimensions between the steel bars. The general guidelines for reinforcement spacing are provided by BS8110-1:1997's close 3.12.11.

2.10. Properties of concrete

2.10.1 Plastic state:

Is the mixing time of the concrete similar to that of "bread dough"? It is pliable and may be shaped or manipulated into a variety of forms. In this stage, plastic refers to concrete. Cohesion and workability are two of plastic concrete's most crucial characteristics.

2.10.2. Setting state

The concrete starts to harden at this point. Setting is the process of hardening concrete until it is no longer pliable.

2.10.3 Hardened state

Concrete starts to harden and acquire strength once it has set. Concrete that has been hardened has two qualities: strength and durability.

The 28th day's compressive strength is frequently used to determine strength specifications. The mix's ability to endure long-term in-situ service conditions is measured by its durability.

2.10.3. Durability of structure made in concrete

Permeability to the entry of water, oxygen, carbon dioxide, and other harmful elements is the primary factor affecting durability. A concrete element that is built to last the entire life of the structure and to properly function in the working environment while shielding embedded metal from corrosion is known as durable concrete. Enyatseng (1998) states that in order to accomplish this, numerous interconnected aspects must be taken into account at different points throughout the design and building process. The following factors impact concrete's durability:

- the cover to the embedded steel
- the shape and bulk of the concrete
- the shape and bulk of the concrete
- the environment
- the type of cement
- the type of aggregate
- the cement content and the water-to-cement ratio
- workmanship

2.10.4. Workability

The ease with which the lowest feasible water/cement ratio can be used to compact concrete mixtures to the maximum extent achievable.

Must be attained by employing an aggregate that is well-graded and has the biggest feasible particle size. Using round and smooth aggregate as opposed to irregularly shaped material improves workability. Although air entraining admixtures increase the workability of mixes, they can result in a 15% reduction in strength. By definition, workability is the capacity of a newly mixed (plastic) concrete mix to appropriately fill a form or mold with the required work (vibration) without lowering the quality of the concrete.

2.11. Concrete

2.11.1. Concrete mixing

During the mixing process, all of the aggregate particles are coated with cement paste with the goal of blinding all of the concrete's constituents into a homogenous mass. Additionally, it is required to mix cement, sand, and coarse aggregate twice: once when dry and once with water added. This ensures that the concrete is homogeneous and of high quality. Both manual and mechanical mixing can be used to achieve this.

Separate paste mixing is typically done in a high-speed, shear-type mixer with a water to cement ratio of 0.30 to 0.45 by mass. Research has shown that mixing cement and water into a paste before combining with materials like aggregates can increase the compressive strength of the resulting Concrete. (Petersen-Nissen, 1989).

Figure 4.2.Hand mixing and **Figure 5.2.Machine mixing**

2.11.2 Compaction of concrete

For concrete to be dense and impenetrable, the body must be strongly compacted. The primary goal of compacting concrete is to remove any trapped air within the material. We compact the concrete because trapped air can cause a 30% reduction in the material's strength. Therefore, it is preferable to release any trapped air. This can be done by compacting the concrete once it has been placed in its final location. It can be accomplished by applying:

1. using a hand rammer
2. Vibration (with machinery)

2.11.3. Compaction by using hand

In this method concrete is compacted by ramming, and tamping, in large portions a pointed steel rod of 16 mm diameter and about 1 m of long is used for poking the concrete into the mold

Figure 6.2.Hand compaction

2.11.4 Compaction by using machine

In order to compact stronger concrete and make it extremely dense and homogenous, this compaction is quite successful. Concrete gains strength and durability through vibrator compaction. When compacting reinforced concrete with a vibrator, the vibrator's needle should be inserted vertically into the concrete; the vibrator shouldn't come into contact with the reinforcement bars. Concrete shouldn't be vibrated for longer than 15 seconds since compaction leads to segregation; the vibrator's tube shouldn't be bent at sharp angles to prevent breakage. Vibrating a concrete surface to compact it is more efficient than doing so by hand. (Concrete, May24, 2016) As soon as cement paste is visible on the concrete's surface, vibration should be halted.

Figure 7.2.Machine compaction

2.12. Curing of concrete

The procedure of keeping freshly laid concrete at the right temperature and moisture content for a predetermined amount of time in order to properly cure the concrete. The process of preventing freshly poured concrete from drying out too rapidly is also referred to as "curing" concrete. One can undergo a 14-day cure to increase one's strength. One way to cure is to:

1. Water spraying: this can be used on columns and walls.
2. Ponding: By allowing the water to stand still, this can be used on horizontal surfaces like slabs and floors.
3. Applying curing compounds: The curing surface may be treated with substances such as calcium chloride. It also prolongs the wetness of the concrete surface. When the curing process goes wrong, concrete loses strength, shrinkage causes fractures to appear, and the structure's longevity decreases.

2.12.1. Reinforced concrete properties

Strong and long-lasting, reinforced concrete can be shaped into a wide variety of sizes and shapes, from a straightforward rectangular column to a thin, curved dome or shell.

Concrete's strength is primarily derived from two materials: steel and concrete. The chart below lists some of the many differences between these two materials' attributes (W.H. Mosley, J.H. Bungey, 1987).

Table 3.2.Property of concrete and steel

PROPERTIES OF MATERIALS	CONCRETE	STEEL
Strength in tension	Poor	Good
Strength in compression	Good	Good but slender bars will buckle
Strength in Shear	Fair	Good
Durability	Good	Corrode if unprotected
Fire resistance	Good	Strength at high temperature

2.12.2. Finishing of concrete

The main reason concrete is utilized is because of its tremendous compressive strength. This is the reason why it's necessary to level and finish the tops of concrete slabs, roads, and walkways in order to apply the proper surface texture. Surface treatments might be more ornate and ornamental, or they can be simple and functional. To provide a high-quality final product, we take into account the:

1. Formwork finishes allow the designer to create a range of styles by allowing the concrete to take on the contour of the form. by thoroughly preparing the formwork. Smooth surfaces can be attained with proper workmanship and property mix design. Units for prefabrication can be created with an excellent finish.

2. Applied finishes: Concrete parts' external surfaces can be altered to provide a visually appealing appearance. The surface of the concrete is cleaned, roughened, and wetted.
3. Surface treatments: The kind of surface treatment chosen is determined by the intended usage of the concrete surface. For instance, the highway's pavement surface should be level but sufficiently uneven to provide skid resistance.

The huge aggregate particles are laid using a wooden float that is moved forward and backward throughout the leveling process. The long straight edge is used to remove hollows and provide a uniform revealed surface. The final phase involves the use of a steel trowel to create a surface that is extremely wear-resistant and smooth. According to Monteiro (1993), troweling should not be done on surfaces that are not floating.

2.13. Fatigue

One process of deformation that mostly affects ductile metals is metal fatigue. Initially, it was believed that a material that was just slightly distorted within the elastic range would fully revert to its initial state if the applied pressures were eliminated. Requirements for failure can range from thousands to millions to billions or trillions of deformations, depending on the material, shape, and degree of deformation towards the elastic limit. (PUNMIA, 2005).

2.13.1 Elastic deformation

This kind of deformation is reversible, meaning it can revert to its initial state. The object returns to its original shape when forces are applied to it. These materials have nonlinear elasticity, in contrast to conventional metals such as ceramics and most crystals, which have linear elasticity and a narrower elastic range. Hooke's law governs linear elastic deformation. It asserts that the slope of the stress and strain curve can be used to determine Young's modulus where the applied stress/strain is equal to Young's modulus. This relationship only holds true within the elastic range. This computation is frequently used by engineers in tensile tests. When the material reaches its yield strength, the elastic range is over (PUNMIA, 2005).

2.13.2 Plastic deformation

This kind of distortion is irreversible, meaning it cannot be reversed. An object in the plastic deformation range, however, will have first experienced reversible elastic deformation, which will cause the object to partially revert to its initial shape. The plastic deformation range of soft thermoplastics is comparable to that of ductile metals like copper, silver, and gold. The plastic deformation range of hard thermosetting polymers, rubber, crystals, and ceramics is very small.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It consists of the theoretical examination of the collection of practices and ideas related to a field of study.

Also is known as the specific procedures or techniques used to identify, select, process, and analyze about a topic.

According to contemporary English Dictionary (1995), a methodology refers to set of methodsand principles that are used when studying a particular kind of work. This Chapter discusses procedures used to conduct the study, focusing on research population, sample size and sampling procedures, research instrument and data analysis methods. In this project concern with design of Reinforced Water storage tank we will prefer to use: Observation supported by interview. To carry out this study, we were distributing the questionnaires to civil engineers, entrepreneurs and other people who have skills on design of water storage tank. We were discussing with them in order to know how they would like this reinforced water storage tank tobe designed. In order to investigate considerations for a design of a water storage tank in Busasamana Sector we used different research techniques for data collection which are documentary analysis, interview, and observation as choice of the research instrument.

3.1 Research Design

The interview method, a crucial qualitative research technique also known as an oral questionnaire, was integral to my project on designing a reinforced concrete water storage tank. This method involves a structured verbal interaction between the researcher and respondents, and it was employed to gather detailed and relevant information for my study.

Preparation:

- Development of Questions: I developed a structured list of questions pertinent to the study, ensuring that they addressed key aspects of the research. These questions were carefully prepared in advance to guide the interviews effectively.

Process:

- Conducting Interviews: During the interviews, I asked questions verbally to the respondents. Their responses were recorded meticulously to ensure accurate data collection.

Advantages:

- High Response Rate: Compared to other methods, interviews often resulted in a higher percentage of completed responses.
- Representative Sampling: This method provided a good representation of the study population, offering insights from various community members.
- Clarity: Personal contact allowed me to explain complex or ambiguous questions in detail, facilitating clearer responses.
- Immediate Feedback: I was able to ask follow-up questions or seek clarification on responses as needed.

Applicability to the Project:

For the water storage tank project, interviews were particularly useful for:

- Gathering Local Knowledge: Obtaining information about water needs and usage patterns within the community.
- Understanding Community Perspectives: Learning about local opinions on the proposed tank location.
- Identifying Challenges: Uncovering potential concerns or issues that residents might have regarding the new water tank.

Considerations:

- Diverse Range of Respondents: Ensured that I included a diverse range of respondents to capture varied perspectives within the Busasamana Sector.
- Language and Cultural Sensitivities: Remained mindful of potential language barriers and cultural differences.
- Time and Resources: Considered the time and resources needed for conducting face-to-face interviews.

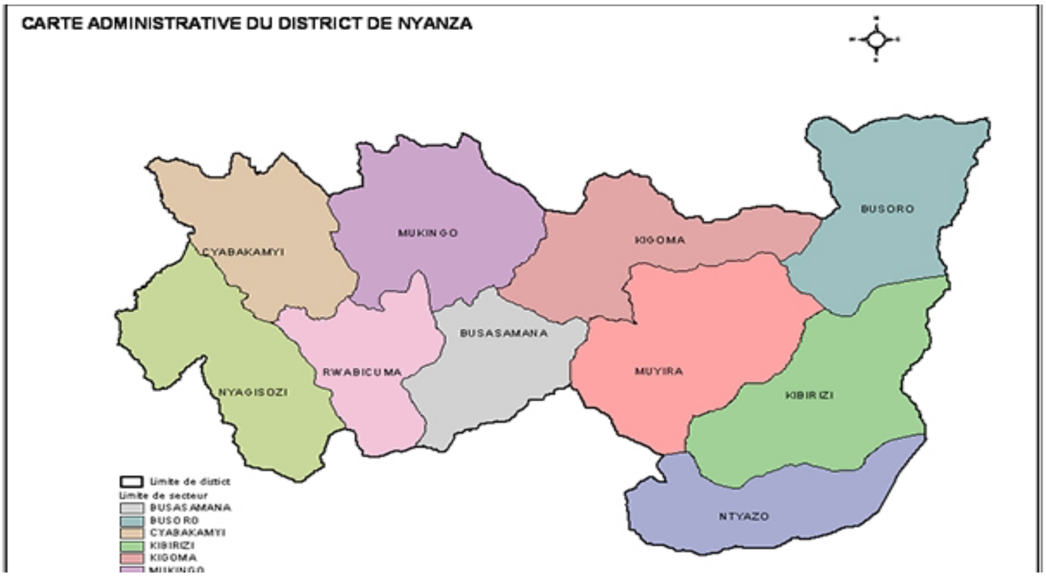
Potential Questions for the Project:

- What are the current water storage and access challenges in your area?
- How would a new water storage tank impact your daily life?
- What concerns, if any, do you have about the construction of a new water tank?

3.1.1 STUDY AREA

The reinforced concrete water storage tank plot is in the Busasamana Sector in the southern province of Nyanza district. It is situated next to the sector office, at the base of the mountain that faces the sector office.

Figure 8.3.Geographical map of Nyanza District



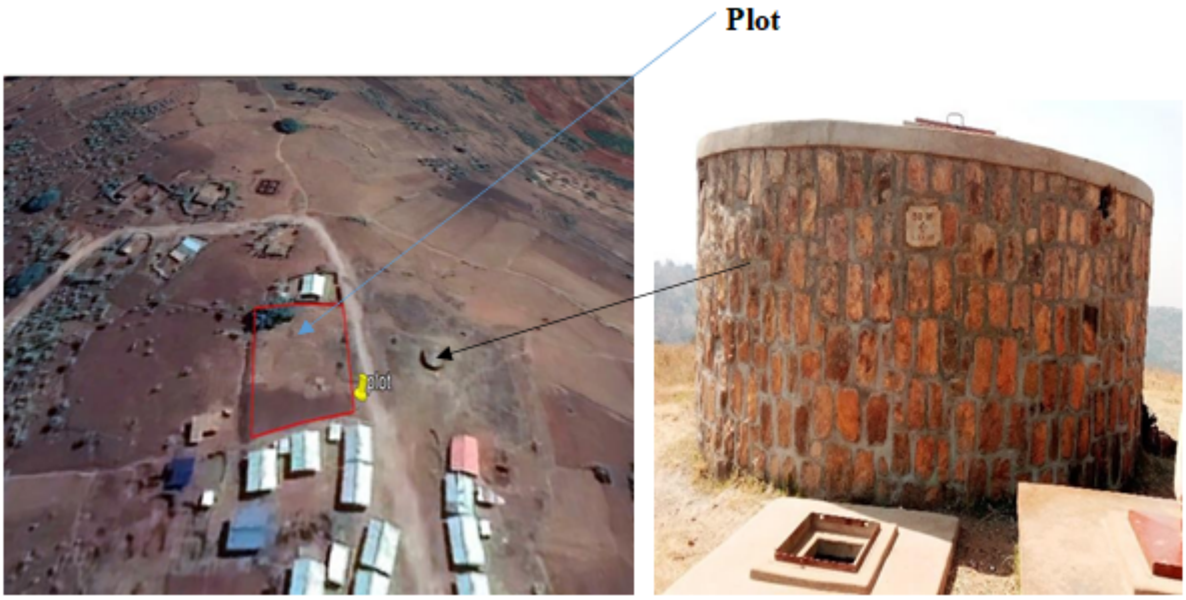


Figure 9.3.Geographic photo (Image from google Map)

3.2 Research population

The people who live in Rwanda's Busasam ana Sector in the Nyanza District were the study population for this research on the design of a reinforced water storage tank. The following were the primary goals in defining this research population:

as a case study, to ascertain the total number of targeted respondents from Nyanza District.

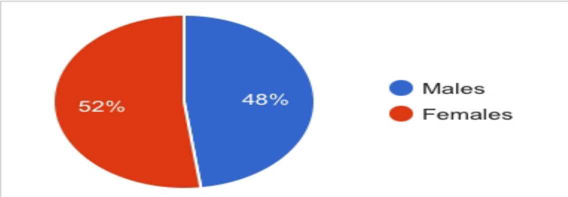
to guarantee that, when put into practice, the suggested reinforced water storage tank design will satisfy population needs in the future.

In order to determine the current population size with accuracy, which is essential for?

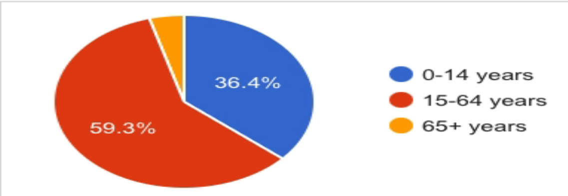
a) Estimating Busasamana Sector's water demand

b) Analyzing the related expenses for the provision of water

Further information about the population structure:



Gender (C 2022)	
Males	24,292
Females	26,369



Age Groups (C 2022)	
0-14 years	18,441
15-64 years	30,042
65+ years	2,178

Figure 10.3.Population structure of Nyanza District

Key demographic information:

Nyanza District total population: 365,718

Busasamana Sector population density: 50,661 people per unit area (specific unit not provided)

Annual population change from 2012-2022: Not specified in the given information, but mentioned as a factor

Methodology:

Residents of the Busasamana Sector were interviewed in order to study the research population.

These interviews most likely assisted in obtaining data regarding:

patterns of water use as of right now

Contentment with the current water supply infrastructures

Future water requirements estimated

Availability of funds to pay for enhanced water services

The study population's importance:

Accurate sizing: By understanding the current and projected population, the water storage tank can be appropriately sized to meet both current and future demands.

Cost estimation: Knowledge of the population served helps in estimating the overall project costs and potential water tariffs.

Sustainability: Ensuring that the design accounts for population growth will contribute to the long-term sustainability of the water supply system.

To further develop this section, you might want to include:

The specific number of respondents interviewed

The sampling method used to select interviewees

Any demographic breakdowns of the research population (e.g., age groups, gender, household sizes)

The exact annual population growth rate, if available

Any challenges faced in accessing or interviewing the research population

3.3 Sample Size

To determine an appropriate sample size that can represent the accessible population of 50,661 in Busasamana Sector, Nyanza District, we will use a statistical approach. The sample size should be large enough to provide reliable results while considering practical constraints such as time and resources.

For this study, we will use the Yamane formula (1967) to calculate the sample size. This formula is widely used in engineering and social science research when dealing with finite populations. The formula is as follows:

$n = N / (1 + N * e^2)$

Where:

n = sample size

N = population size (50,661)

e = margin of error (we will use 5% or 0.05)

Applying the formula:

$n = 50{,}661 / (1 + 50{,}661 * 0.05^2)$

$n = 50{,}661 / (1 + 126.6525)$

$n = 50{,}661 / 127.6525$

$n \approx 397$

Therefore, a sample size of 397 individuals would be sufficient to represent the population of 50,661 with a 95% confidence level and a 5% margin of error.

The table for calculating sample size from a given population by Krejcie and Morgan (1970) supports this sample size. As to their table, a sample size of 381 is suggested for a population of 50,000. The fact that our estimated sample size of 397 somewhat surpasses this advice increases

the validity of our findings.
We will expand our sample size by 10% to 437 people in order to accommodate for probable non-responses or erroneous data. This change will make it more likely that we will maintain the appropriate degree of accuracy even in the event that some responses are useless.

3.3.1 Sampling Procedure

The sampling procedure is crucial to ensure that the selected sample accurately represents the population of 50,661 in Busasamana Sector, Nyanza District. To achieve this, we employed a stratified random sampling method, which combines the benefits of randomization with the assurance that key subgroups of the population are adequately represented.
The procedure was as follows:
Population Stratification: The population was divided into strata based on key demographic factors such as age groups, gender, and residential areas within the sector.
Proportional Allocation: The number of participants selected from each stratum was proportional to the size of that stratum in the population, ensuring fair representation.
Random Selection: Within each stratum, participants were selected using a random number generator to avoid bias.
Sample Size Determination: The sample size was calculated using Slovin's formula with a 95% confidence level and a 5% margin of error, resulting in a sample size of 397 participants.
Data Collection: Structured questionnaires and interviews were used to gather information from the selected participants regarding their water usage patterns, storage needs, and preferences.
This sampling procedure ensures that the selected sample is representative of the population in Busasamana Sector, allowing for accurate extrapolation of findings to inform the design of the reinforced water storage tank.

3.4 Research Instrument

Research Instruments for the Reinforced Concrete Water Storage Tank Project
Types of Research Instruments:
For my project on designing a reinforced concrete water storage tank, I utilized the following research instruments:
1. Questionnaires
2. Interview Guides
3. Observation Checklists
Selection Process:

In selecting the appropriate research instruments for my study, I considered the following:
- Instruments Used: I used questionnaires and interview guides to collect qualitative and quantitative data from respondents. Observation checklists were employed to systematically record findings during site assessments.
- Type of Instrument: The questionnaires and interview guides were researcher-devised, tailored specifically to the needs of my project. The observation checklists were based on standardized templates relevant to construction and engineering.

Basis for Instrument Content:
- Literature Review: The content of the questionnaires and interview guides was informed by aspects discussed in the Review of Related Literature. This approach ensured that the questions were grounded in existing research and relevant to the study's objectives.
- Foundation: I avoided developing questions without a solid foundation by relying on established theories and best practices in structural engineering and water storage systems.

For Researcher-Devised Instruments:
- Pre-testing: I conducted a pre-test of the questionnaires and interview guides with 5-10 subjects who were not included in the actual study. This helped in refining the questions and ensuring clarity and relevance.
- Reliability and Validity: I tested the reliability and validity of the researcher-devised instruments through iterative feedback and adjustments based on pre-test results.

For Standardized Instruments:
- Author Information: For standardized observation checklists, I referred to established guidelines and acknowledged the authors and sources of these instruments.
- Permission: I obtained and acknowledged the necessary permissions to use these standardized instruments in my project.
Discussion of Instrument Characteristics
- Response Modes: I employed a combination of multiple-choice, Likert scale, and open-ended response formats to gather diverse types of data.
- Scoring Methods: The responses were scored using predefined criteria and scales to quantify and analyze the data effectively.
- Interpretation of Scores: The interpretation of scores was based on established benchmarks and guidelines relevant to the field of water storage tank design.

By carefully selecting and utilizing these research instruments, I ensured the comprehensive and reliable collection of data for my project on reinforced concrete water storage tank design.

Validity and Reliability of the Instrument

Focusing on Validity and Reliability in the Structural Analysis and Design of a Reinforced Concrete Water Storage Tank

As part of my project on designing a reinforced concrete water storage tank, I have concentrated on ensuring the validity and reliability during the structural analysis and design phase, which is critical to the project.

Structural Analysis and Design.

Validity:

In structural analysis, content validity is particularly crucial. My analysis covers all essential aspects of the tank's structural behavior, including:

- Static loads such as water pressure and self-weight
- Dynamic loads such as seismic activity and wind loads if applicable
- Soil-structure interaction for both ground-level and underground tanks
- Thermal stresses due to temperature variations
- Creep and shrinkage effects in concrete

To ensure construct validity, I have:

- Used well-established theories of reinforced concrete behavior
- Applied appropriate design codes, such as ACI 350 for environmental engineering concrete structures
- Considered specific requirements for water-retaining structures, focusing on crack control and water-tightness

For criterion validity, I have:

- Compared my design outputs with existing successful water tank designs
- Verified that my results meet or exceed the requirements set by relevant standards

Reliability:

To demonstrate reliability in my structural analysis, I have:

- Performed calculations using different methods, such as manual calculations and computer software, and compared the results

- Used multiple software packages like SAP2000 and STAAD.Pro to cross-verify outputs
- Conducted sensitivity analyses by slightly varying input parameters to ensure stable results

Specific Instruments and Methods:

a) Finite Element Analysis (FEA) Software:

- Validity: Ensured the software is appropriate for reinforced concrete and fluid-structure interaction analysis
- Reliability: Conducted mesh sensitivity studies to ensure results are not significantly affected by mesh size.

b) Concrete Mix Design Tools:

- Validity: Used tools that incorporate the specific requirements for water-retaining structures, such as low permeability and sulfate resistance
- Reliability: Performed multiple trial mixes and tests to ensure consistent results

c) Reinforcement Detailing Software:

- Validity: Verified that the software adheres to the relevant design codes for water tanks
- Reliability: Cross-checked software outputs with manual calculations for critical sections

Establishing Validity and Reliability:

To establish the validity and reliability of my structural analysis and design, I have:

a) Expert Consultation:

- Consulted with experienced structural engineers specializing in water tanks
- Had my methodology reviewed by my academic supervisor.

b) Literature Review:

- Compared my approach with peer-reviewed research on reinforced concrete water tanks
- Incorporated best practices from case studies of similar projects

c) Sensitivity Analysis:

- Varied key parameters such as concrete strength and reinforcement ratio to analyze the impact on results
- This helped establish the robustness of my design

d) Documentation:

- Clearly documented all assumptions, input parameters, and calculation methods
- This allowed for peer review and increased the reproducibility of my results

e) Physical testing (if possible):

- While full-scale testing may not be feasible, considered small-scale models to verify certain aspects of my design
- For instance, tested concrete samples for permeability and strength

Addressing Limitations.

I have acknowledged limitations in my approach, such as:

- Idealized loading conditions that may differ from real-world scenarios.
- Assumptions made in soil-structure interaction modeling.
- Limitations of the software or design codes used.

By elaborating on these aspects, I have demonstrated a thorough understanding of the validity and reliability considerations in my structural analysis and design process. This rigorous approach enhances the credibility of my final year project on reinforced concrete water storage tank design. Framed

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3.5 Data Gathering Procedures

The following steps were taken to collect the necessary data for designing the reinforced water storage tank:

- **Preliminary Research**: Review of existing literature on water storage tank design Study of local building codes and regulations
  Analysis of similar projects in the region
- **Site Assessment**: Site visit to Busasamana Sector
  Topographical survey of the proposed tank location Soil testing to determine ground conditions
- **Population Data Collection**: Obtaining current population data (50,661) from local authorities
  Analysis of population growth trends in the area
- **Water Demand Assessment**: Surveys or interviews with local residents about water usage
  Collection of data on existing water supply systems
- **Climate Data Gathering**: Obtaining rainfall data from local meteorological stations
  Analysis of seasonal variations in water availability
- **Structural Requirements**: Consultation with local engineers on seismic considerations
  Review of available construction materials in the area
- **Stakeholder Engagement**: meetings with local government officials
  Discussions with community leaders and potential end-users
- **Technical Specifications**: Determination of required tank capacity based on population and demand Calculation of structural loads and reinforcement requirements.
- **Environmental Considerations**: Assessment of potential environmental impacts
  Identification of mitigation measures
- **Cost Estimation**: Gathering of current prices for materials and labor
  Estimation of construction and maintenance costs

3.6 Data Analysis and interpretation

The interview method, also known as an oral questionnaire, was a crucial tool in gathering data for my project on the design of a reinforced concrete water storage tank. This process involved directly asking respondents for information through verbal interaction. Prior to conducting the interviews, I prepared a list of structured questions relevant to the study to guide the discussions with respondents and gather their opinions on the subject matter.

During the interviews, I posed questions to the respondents and meticulously recorded their answers. This method offered several significant advantages, as highlighted by AINA (2004):

1. High Response Rate: The personal interaction typically leads to a higher response rate compared to other data collection methods.

2. Representativeness: The method tends to be more representative of the entire population under study.

3. Clarification: Personal contact between the researcher and respondents allows for the clarification of any confusing or ambiguous questions in detail.

The data collected through these interviews were analyzed using various techniques and software to ensure accuracy and comprehensiveness. The following tools and methods were employed in my project:

Engineering Software:

- ArchiCAD and AutoCAD: Used for creating detailed drawings of the water storage tank.
- Microsoft Office Suite:
- Microsoft Word: Used for documenting the project.
- Microsoft Excel: Used for the computation of loads and other calculations.
- Microsoft PowerPoint: Used for the presentation of the project.

By employing these techniques and tools, I was able to thoroughly analyze the data collected and ensure the integrity and reliability of the findings in my project on designing a reinforced concrete water storage tank.

3.7 Ethical considerations

Throughout its implementation, this project—which focuses on designing a reinforced water storage tank for a municipality with a population density of 50,661—prioritizes ethical behavior. The following actions have been taken to guarantee the security, social welfare, and mental health of the concerned persons and the community:

Institutional Review: Before starting the experiment, permission from the university's Ethics Committee was requested and granted. The project's compliance with accepted ethical standards for engineering research and community-based initiatives was guaranteed by this evaluation procedure.

Community permission: Local government officials and community leaders in the Busasamana Sector provided their informed permission. This required outlining the goals, possible effects, and advantages of the project in order to guarantee accessibility and support from the local community.

Environmental Impact Assessment: To identify and lessen any possible harm that the water storage tank could have to the neighborhood's ecosystem and community, a preliminary environmental impact assessment was carried out.

Safety Considerations: In accordance with national and international construction norms and standards for reinforced concrete buildings, the design process places a high priority on the water storage tank's structural integrity and safety.
Water Quality Assurance: To protect the public's health, the design includes measures to preserve the water quality inside the tank.
Cultural Sensitivity: The project respects community values and land use patterns by designing and placing the tank in a way that corresponds with local cultural norms and practices.
Engagement of Stakeholders: Throughout the project, regular consultations have been held to address issues and incorporate feedback with members of the community, local water management agencies, and other pertinent stakeholders.

Data protection: All private or sensitive information gathered for the project, such as demographic information and patterns of water use, is kept private and utilized only for this research. Sustainable Development: By enhancing community water access and management while taking long-term social and environmental effects into account, the initiative seeks to support sustainable development objectives.

Transparency: The project's ethical standing can be verified and peer reviewed thanks to the transparent documentation of all findings, computations, and design choices.
In addition to providing a technically sound water storage system, the project seeks to guarantee that it is conducted in a way that respects and benefits the community of Busasamana Sector by abiding by these ethical standards.
Note: As stated in the original instructions, Appendices II and III, which refer to consent forms and ethical clearance papers, should be added to your project report.

3.8 Limitations of the study

Data accuracy: Population projections and water demand estimates may have inherent uncertainties.
Site-specific conditions: Soil properties and geological factors unique to Busasamana may limit generalizability.
Time constraints: The study's duration may limit long-term performance assessment.
Budget limitations: Financial constraints may restrict the scope of materials testing or analysis.

Technical expertise: Limited access to specialized engineering knowledge could affect design optimization.

Environmental factors: Unforeseen climate changes may impact long-term tank performance.

Regulatory changes: Future policy shifts could affect design compliance.

To minimize these limitations:

Use multiple data sources and conduct sensitivity analyses

Perform thorough site investigations

Implement a phased approach for long-term assessment

Prioritize critical tests within budget constraints

Consult with industry experts and academic resources

Consider climate projections in design

Design for adaptability to potential regulatory changes

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

The RCC design is crucial step in a building construction. The RC design is done to make safe structure. The major structural members in reinforced concrete structures comprise slabs, beams, columns, footings. They are reinforced against cracks. This project of structural design of Reinforced concrete water storage tank is located in NYANZA district, BUSASAMANA Sector.

A reinforced concrete building structure is a combination of beams, columns slabs and walls rigidly connected together to form a monolithic frame. The design of an engineering structure must ensure must ensure that under the worst loading the structure is safe, and during the normal working conditions the deformation of the members does not detract from the appearance, durability or performance of the structure. Each individual member must be capable of resisting the forces acting on it, so that the determination of these forces is an essential part of the designprocess. (WH Mosley and JH bungey, 1998).

Population forecasting techniques in Busasamana Sector

When the design period is fixed the next step is to determine the population of a town or city. Population of a town depends upon the factors like births, deaths, migration and annexation. Based on (Ahmed Essam Mansour, 2005)

But we were determining population according to the number of births. The future developmentof the town mostly depends upon trade expansion, development industries, and surrounding country, discoveries of mines, construction of railway stations etc. may produce sharp rises, slow growth, and stationary conditions or even decrease the population. For the prediction of population, it is better to study the development of other similar towns,

Which have developed under the same circumstances, because the development of the predicted town will be more or less on the same lines.

The following are the standard methods by which the forecasting population is done.

- Arithmetical increase method
- Geometrical increase method
- Incremental increase method

Population forecasting by using arithmetic method (data from social sector affair office)

This method is based on the assumption that the population is increasing at a constant rate. The rate of change of population with time is constant. The population after 'n' decades can be determined by the formula. (Mark J. Hammer)

Pn = P + n.c

Where: **P** → Number of the present population

Pn → Number of the population at time n[th] time unit

n → No. of decades

c → Constant determined by the average of increase in population

Table 4.4.Population forecasting by using arithmetic method (social sector affair office)

NO	YEAR	Population	Increase in population
1	2010	25864	---
2	2015	27659	1795
3	2020	30559	2900
		TOTAL	4695
		AVERAGE	4695/2= **2347.5**

Expected population in 2050 = 30559+ 6*2347.5 = **44644 people**

Depending upon the design standard for clear water storage tank as 28 years that is why we design a water storage tank which has capacity for supplying 44644 people in 2050.

4.2. To determine per capital water demand

The quantity of water required in the houses for drinking, bathing, cooking, washing etc. is called domestic water demand and mainly depends upon the habits, social status, climatic conditions and customs of the people.

Under normal conditions, the domestic consumption of water developing countries is about 135 liters/day/capita. But in developed countries this figure may be 350 liters /day/capita because of use of air coolers, air conditioners, maintenance of lawns, automatic household appliances. In order to design water this reinforced water storage tank we prefer to design circular water storage tank with a flexible base and in order to determine the quantity of water requiredby one person per day.

The water needed by one person per day are detailed below by According to world health organization standard:

Cooking: 10liters

Toilet and bathing: 10liters

Cleaning house: 7liters

Drinking: 3liters

Cloves washing: 15liters

The capacity of water storage tank in BUSASAMANA Sector which has consumers 44644people is 100liters per person per day in 2050, 45* 44644= **2**008980liters

The amount of water consumed by occupants in this sector is 2008980liters or2009m^3 per day during our site visit, also we get that 65Liters per capita per day is sufficient.

Design of tank capacity = 44644*65L = 2008980L, 2009m^3

Tank capacity required = **2009m^3**

4.3. Methods for designing water storage tank

Scientific evidences revealed that the process of designing a water storage tank, either in the dry season demand and supply method are used. In order to determine the required tank volume, the day of longest dry period is multiplied by the amount of water required per day. For instance, to supply 100 liters per day per house accommodate a 50-day dry period the required storage volume is 100^x 50= 5000m^3 (Jordan, 1983). This method gives only a rough estimate of the storage required.

4.4. Discussion

Before an appropriate tank size can be calculated, the ultimate use of the water must be determined. How many people relied on the water, water to be used depending on the construction material selected, a personal holding tank may still to be very expensive. A variety of options of water tank construction materials.

4.5. Calculations of water tank design

This included all the calculations that lead to the true proportions/ dimensions of the designed water storage tank. It shows also the estimated cost for the proposed project as well as all the specifications for some construction materials and drawings for the project.

In order to determine the preliminary and final design parameters of water storage tank design, some data have been collected and basic calculations done.

Ultimate state method of design

Limit state design based on:

Ultimate limit state

Serviceability limit state

The maximum crack doesn't exceed of 0.2mm

The tensile strength of the reinforcement (fy) not exceed 425N/mm^2

This application a limit state uses recommendation from BS 8110 subjected to modification contained in BS 5337.

Dimension of the tank

- Volume of tank = 2009m^3
- Total height of tank = 10.2m
- Free board height = 0.2m
- Tank useful height = 10.2 – 0.2 = 10m
- Concrete grade = C20
- Permissible stress of steel in tension = 150N/mm^2
- fcu: The compressive strength of the concrete = 30N/mm^2
- fy: The tensile strength of the reinforcement = 425N/mm^2

Cross-section of tank===200.9 m^2

Diameter of tank=

= **= 15.99m then let use 16m tank diameter**

4.6. Ultimate limit state

Thickness of the wall= 350mmImposed load = 2KN/m^2 Finishes= 1.5KN/m^2

Self-weight of wall= 0.35*24=8.4KN/m^2Load from cover = 0.2* 24 = 4.8KN/m^2

Total dead load= Self weight + finishes: 8.4+4.8+ 1.5 = 14.7KN/m^2Design load

= 1.4GK +1.6QK, 1.4 *14.7 +1.6*2 =23.78KN/m^2

H= 350mm,

Let assume C= 40mm, ∅ =10mm d= h-c- ∅ /2, 350-40-10/2 =305mm

Load applied on the wall Water pressure (P): p*g*hWhere:

p= density of water in kg/m^3 (1000kg/m^3)

g: gravitation force in m/s^2(9.81m/s^2)

h= height in m

P= 1000×9.81×10=98100Pa = 98.1KN/m^2

Self- weight of wall = 0.35m×25KN/m^3= 8.75KN/m^2Total dead load

(Gk)= 9.81+8.75+1.5= 20.06KN/m^2 Live load: 2KN/m^2

Design load (: 1.4GK+1.6QK =1.4*20.06+1.6*2= 31.284KN/m^2

Design moment (M) == = 391.05KNm

Ultimate Moment = 0.156fcubd^{2}Mu = 0.156fcu bd^2

Mu= 0.156*30*1000*305^2 * 10^{-6} = 435.35KNm

Mu>M means no reinforcement required.Ultimate moment: 435.35KNm

- As=
- K=

d= h-c-∅ /2

d= 350-40-10/2= 305mm

K = 0.155<0.156 no compression reinforcement steel required

Z = 305(0.5+)

Z=305(0.5 +) =0.77d

Therefore, lever arm factor z =0.77d

As=

As=

=5013.48mm^2/m

Provide T32@200mm c/c (As prov = 5360mm^2/m)

a) Serviceability limit state

Flexural cracking: check service stress in reinforcement assuming crack section

Let using an estimated E_C = 26KN/mm^2

Modular ratio α_e=

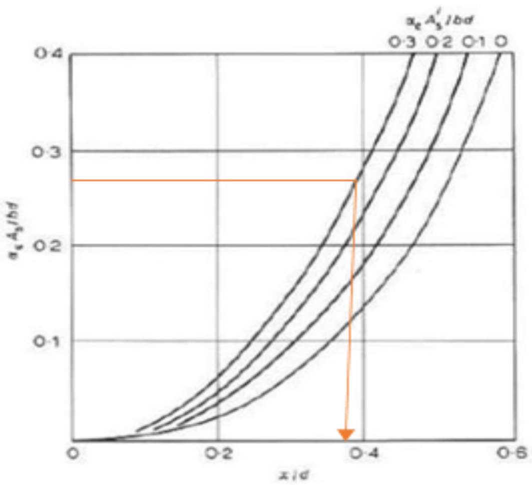


Figure 12.4.Neutral axis depths for cracked rectangular section-elastic behavior

a) Neutral axis

(X) =0.39d, 0.39*305,

X= 118.95

Fs= = =327.25N /

327.25N/mm^2 > 115N/mm^2 (Allowable for plain bar)

b.) Thermal cracking

Maximum spacing: ∫max= * Where r=

= 1 (For plain bar)

∫max= 1* = 1044.77 mm

c) Maximum width of cracks (Wmax)

Wmax= ∫max*

Let use $T^o = 30^o$

άc= $10*10^{-6}$

άc =

W max= 1044.77* = 0.15mm < 0.2mm OK because the maximum cracks in water Retaining structures is 0.2mm

b) Reinforcement and joint detailing

Critical ratio r_{crit}=

Tensile strength (fct) = $1.3N/mm^2$

r crit= = 0.003

As = b*h *0.003

= 1000*350*0.003= $1050mm^2/m$

Provide T16@150mm c/c (Area = 1340mm²/m)

Let take T32@200mm c/c for Area provide = $5360mm^2/m$ because considered all crack shrinkage effect and temperature

Bending reinforcement

As =

- K =

Where Z = d (0.5- 0.25-k/0.9)

- d = thickness - Ø/2 – covered

  d=350- 10/2 -25 = 320mm

- K=

= 0.141 < 0.156 no completion steel reinforcement required

- +)

Z= 305(0.5+) =0.80d

-

- Provide T25@100mm C/C (Aprov = 4910mm^2/m)

Distribution steel

For distribution steel provide area of minimum

- Since thickness = 350mm which is between 100 and 450,
- As min = $\frac{0.13bh}{100}$
- $\frac{0.13 * 1000 * 350}{100}$ =455mm^2/m
- Provide T12@ 200mm c/c

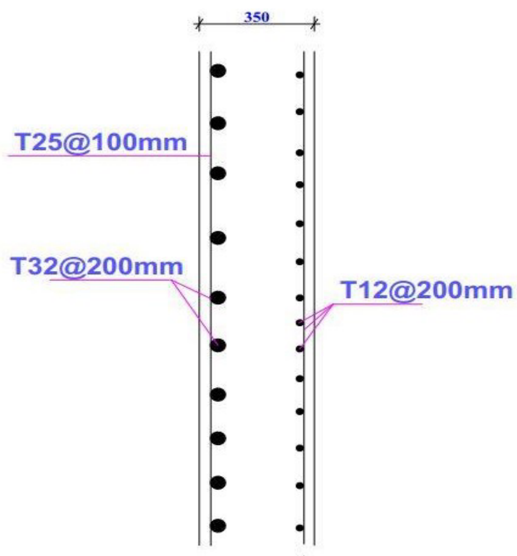


Figure 13.4.Wall element details

4.7. DESIGN TOP SLAB (COVER) BS8110Calculation of loading

dmin> , assuming Mf=1.4

dmin> = 219.78mm, lets take **220mm**

h= dmin+C+

let's assume the diameter of bars=10mm
cover to the reinforcements=25mm

h= 220+25+ =**250mm**

Fcu =30 N/mm^2
Fy=425N/ mm^2

Finishes= 1.5KN/m^2(BS6399:pt1 clause 5.1.1. Minimum imposed floor loads)
The overall depth (h) = **250mm**

Types of slab: Two adjacent edge discontinuous
The reinforcements will be provided on cover same as reinforcements provided on base slab because both have same overall depth.
Self-weight= 0.25m*25KN/m^2*1m = 6.25KN/m^2
Dead load (GK)= 6.25KN/m^2+ 1.5KN/m^2= 7.75KN/m^2
Live loads (QK): 2KN/m^2
The ultimate design load due to the self-weight of the slab and the finishes,
N = (1.4Gk + 1.6Qk) (BS 8110 part 1, 1997) clause 3.2.1.2.2
N= 1.4*7.75+1.6*2 = 14.04KN/m^2

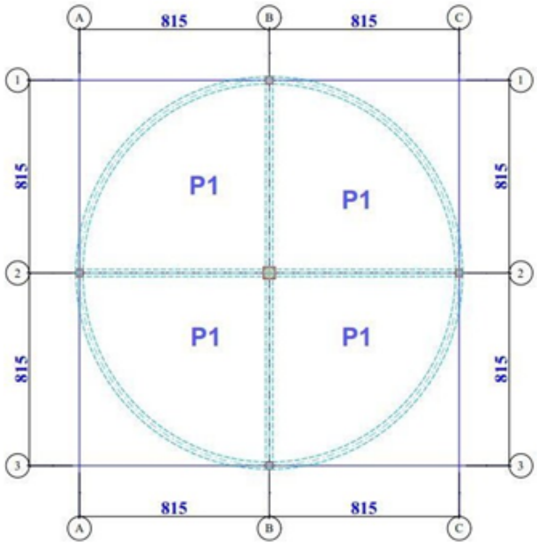


Figure 14.4.Beam, column and panel layout

						Coefficients, βsxand βsy at support		Coefficients, βsx and βsy at midspan		Bending momentsat support		Bending momentsat mid span	
PANEL	L_X (m)	L_y (m)	L_x/L_y	LX2	N (KN/m)	Bsx	βsy	βsx	βsy	Msx	Msy	Msx	Msy
P1	8.15	8.15	1	66.42	14.04	0.047	0.045	0.036	0.034	43.82	41.96	33.57	31.7

From the table above, it is obviously seen that the all panels are same loaded with the followingmoments:

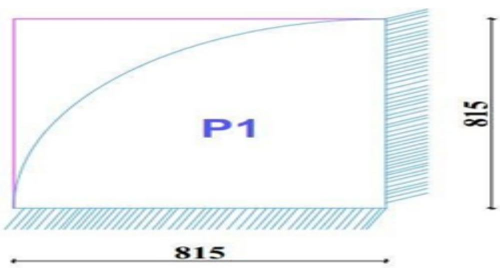


Figure 15.4.Two-way slab panels

Maximum Moment at the support Msxn=43.82KNm,

Msyn=41.96KNm**Maximum Moment at mid-span**: Msxp: 33.57KNm,

Msyp=31.7KNm **Formula to calculate moment at support and at middle**

The moments at mid span and at the support of the two ways slabs, where the moments are found by using these formulas based BS8110):

$\mathbf{Msxn} = \beta\mathbf{sxn} \times \mathbf{n} \times \boldsymbol{Lx}\mathbf{2}$ negative moment in the direction of Lx at the support

$\mathbf{Msyn} = \beta\mathbf{syn} \times \mathbf{n} \times \boldsymbol{Lx}\mathbf{2}$ negative moment in the direction of Ly at the support

$\mathbf{Msxp} = \beta\mathbf{sxp} \times \mathbf{n} \times \boldsymbol{Lx}\mathbf{2}$ positive moment in the direction of Lx at the mid span

$\mathbf{Msyp} = \beta\mathbf{syp} \times \mathbf{n} \times \boldsymbol{Lx}\mathbf{2}$ positive moment in the direction of Ly at the mid span

- **Design of steel reinforcement (clause 3.5.4, BS 8110)**

Maximum Moment at the support

Msxn=43.82KNm

Msyn=41.96KNm

- **Main steel**

Msxn=43.82KNm

K= ==0.03< 0.156

Since K<0.156 means there is no compression reinforcement required.

Hence find lever arm using the following formula:

Z = 170[0.5 + (√ (0.25 – 0.03/0.9)] = 0.95d

So, the critical Z is 0.95*d = 0.95*220 = 209mm

As=

As= = 567.04

As min=0.13%bh= 0.13%*1000*250 = 260mm^2/m

From steel reinforcement table, we provide **T10@125mm for As prov= 628mm^2**

- **Second steel**

Msyn= 41.96KNm

d= h-c- ∅ /2 = 250-25-10/2 = 220mm

d' = h-c-∅ -∅ /2 = 250-25-10-10/2 = 210mm

K= = = 0.031<0.156

Since K<0.156 means there is no compression reinforcement required.

Z= d (0.5+ = 0.96d>0.95d

So, the critical Z is 0.95*d = 0.95*210 = 199.5mm

As= = = 568.83 /m

From steel reinforcement table, we provide **T10@125mm** for As $_{prov}$= 628mm^2/

Maximum at mid-span Msxp=33.57KNm Msyp=31.7KNm

- **Main steel**

Msxp=33.57KNm

K= = = 0.023< 0.156

Since K<0.156 means there is no compression reinforcement required.

Z= d (0.5+ = 0.97d>0.95d

So, the critical Z is 0.95*d = 0.95*220 = 209mm

As= = = 434.4

From steel reinforcement table, we provide **T10@175mm** for As $_{prov}$= 449mm^2/m

- **Second steel**

Msyp=31.7KNm

K= = =0.023<0.156

Since K<0.156 means there is no compression reinforcement required.

Lever arm = 0.95d, 0.95*210= 199.5mm

As = = = 429.74

From steel reinforcement table, we provide **T10@175mm** for $A_{s\ prov}$= 449mm^2/m

Check deflection

Actual span/d = = 37.04

Mf = 0.55+ ≤ 2.0 where

Fs = *fy**

Fs = *425 ** = 239.84$N/mm2$

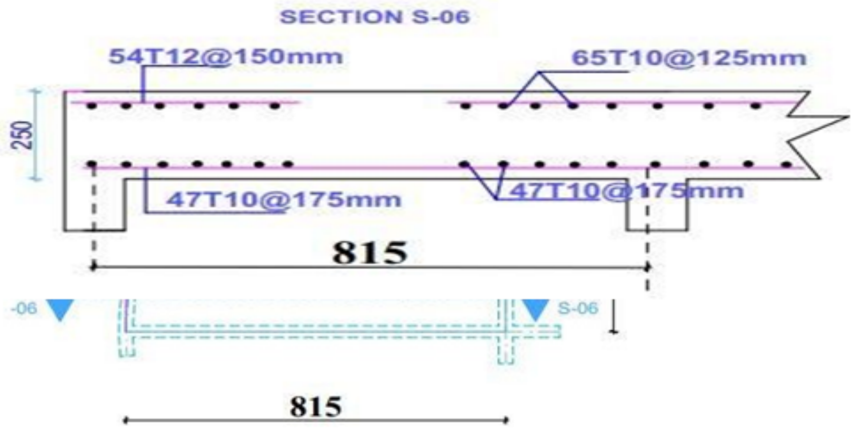
Mf= 0.55 + = 1.78<2, Mf must not greater than 2

(BS 8110 pt1, clause 3.4.7. table 3.10. modification factor for tension reinforcements)

=basic ratio * M. F

=26*1.78=46.28; thus 46.28>37.04

Therefore the slab is safe against deflection (no deflection)



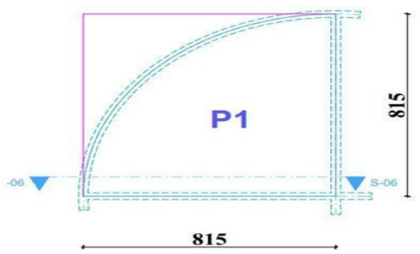


Figure 16.4.slab cover element details

4.8. DESIGN OF BASEMENT SLAB (GROUND SLAB)

Calculation loading

Finishes= 1.5KN/m^2 (BS6399:pt1 clause 5.1.1. Minimum imposed floor loads)the overall depth (h) = **300mm**

Fcu =30
N/mm^2
Fy=425N/
mm^2

Let's assume the diameter of bars=10mm

Cover to the reinforcements=25mm
d= h-c-∅ /2=300-25-10/2= 270mm
Types of slab: Two adjacent edge discontinuous

The reinforcements will be provided on cover same as reinforcements provided on base slab because both have same overall depth.

Load from water: (p*g*h), 1000*9.81*10 = 98.1KN/m^2

Self-weight= 0.3m*25KN/m^2*1m = 7.5KN/m^2

Dead load (GK) = 7.5KN/m^2+ 98.1+1.5KN/m^2 = 107.1KN/m^2

Live loads (QK): 2KN/m^2

The ultimate design load due to the self-weight of the slab and the finishes, N = (1.4Gk + 1.6Qk) (BS 8110 part 1, 1997) clause 3.2.1.2.2

N= 1.4*107.1 +1.6*2 = 153.14KN/m^2

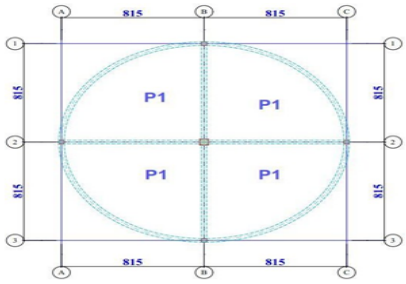


Figure 17.4.Beam, column and panel layout

						Coefficients, βsxand βsy at support		Coefficients, βsxand βsy at mid span		Bending momentsat support		Bending momentsat mid span	
PANEL	L_x(m)	L_y (m)	L_x/L_y	LX2	N (KN/m)	Bsx	βsy	βsx	βsy	Msx	Msy	Msx	Msy
P1	8.15	8.15	1	66.42	153.14	0.047	0.045	0.036	0.034	478.06	457.72	366.17	345.83

From the table above, it is obviously seen that the all panels are same loaded with the following moments:

$M_{sxn} = \beta_{sxn} \times n \times L_x^2$ negative moment in the direction of Lx at the support

$M_{syn} = \beta_{syn} \times n \times L_x^2$ negative moment in the direction of Ly at the support

Msxp = β**sxp** × **n** × $\boldsymbol{Lx2}$ positive moment in the direction of Lx at the mid span

Msyp = β**syp** × **n** × $\boldsymbol{Lx2}$ positive moment in the direction of Ly at the mid span

Maximum Moment at the support Msxn=478.06KNm, Msyn=457.72KNm

Maximum Moment at mid-span: Msxp: 366.17KNm, Msyp=345.83KNm

Formula to calculate moment at support and at middle

The moments at mid span and at the support of the two ways slabs, where the moments arefound

By using these formulas based BS8110):

Design of steel reinforcement (clause 3.5.4, BS 8110)

Maximum Moment at the support

Msxn=478.06KNm

Msyn=457.72KNm

- **Main steel**

Msxn= 478.06KNm

K= = = 0.218<0.156

Since K>0.156 means the compression reinforcement is required.

Hence find lever arm using the following formula:

Ultimate moment (Mu) = $0.156fcubd^2 = 0.156*30*1000*270^2$=341.17KNm

M> Mu, means compression reinforcement is required in base slab

$d' = C + h' + \theta/2$ = 25+10+10/2=40mm

Area for compression

$As' =$ = = 1609.66

Provide 16T@125mm (Area provided 1610mm^2/m)

Area of tension steel: As =

Lever arm = Z = d[0.5 + (]

Z= 270[0.5 + (√ = 209.75mm

As= = 4399.06 mm^2/m

Provide 25T@100mm (Aprov: 4910mm^2/m)

As min=0.13%bh= 0.13%*1000*300 = 390mm^2/m

From steel reinforcement table, we provide **T10@125mm for As prov= 628mm^2**

- **Second steel**

Msyn= 457.72KNm

K= = = 0.209>0.156

Since K> 0.156 means that compression reinforcement is required.
Area of compression, Assume diameter of compression steel θ=25mm, diameter of links θ' = 8mm and cover of reinforcement C is 25mm. Hence effective compression steel d$'$ is
d$'$ = C + h$'$ + θ /2 = 25+8+25/2= 46mm

As' = = = 1407.2/m

Provide steel 12T@75mm Asprov= 1510mm^2

Area of tension steel: As =
Lever arm = Z =d [0.5 + (]
Z= 270[0.5 + (] = 209.75mm
As= = 4398.86 /m

From steel reinforcement table, we provide 25T@100mm for Aspro= 4910mm^2/m

Maximum at mid-span
Msxp=366.17KNm
Msyp=345.83KNm

- **Main steel**

Msxp=366.17KNm

K= = = 0.167 > 0.156

Since K>0.156 means that compression reinforcement is required.

Area of compression steel

As' = = = 301.84

Provide 10T@125mm c/c (Area provided 628mm^2/m)

Lever arm = Z = d [0.5 + (]

Z= 270[0.5 + (] = 209.75mm

= 4399.06

From steel reinforcement table, we provide **25T@100mm for As prov= 4910mm^2/m**

- **Second steel**

Msyp=345.83KNm

K== = 0.154<0.156

Since K>0.156 means that no compression reinforcement required.

Lever arm = Z = d[0.5 + ($\sqrt{}$(0.25 − 0.154/0.9)]=0.78d

Z= 0.78*270 =210.6mm

=As=4441.15mm2/m

From steel reinforcement table, we provide **25T@100mm for Aspro= 4910mm^2/m**

Check crack on slab

Maximum spacing between bars should not exceed the lesser of 3d (3*270 mm) or 810 mm.

Actual spacing= 125 mm main steel and secondary steel (125< 810). Ok (no crack on slab)

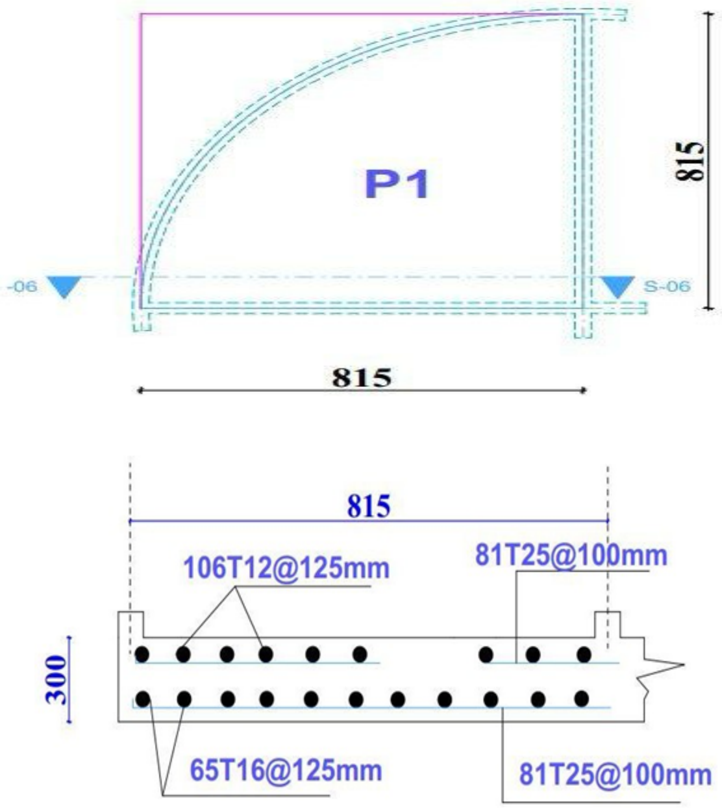


Figure 18.4.Ground slab element details

4.9DESIGN OF BEAM

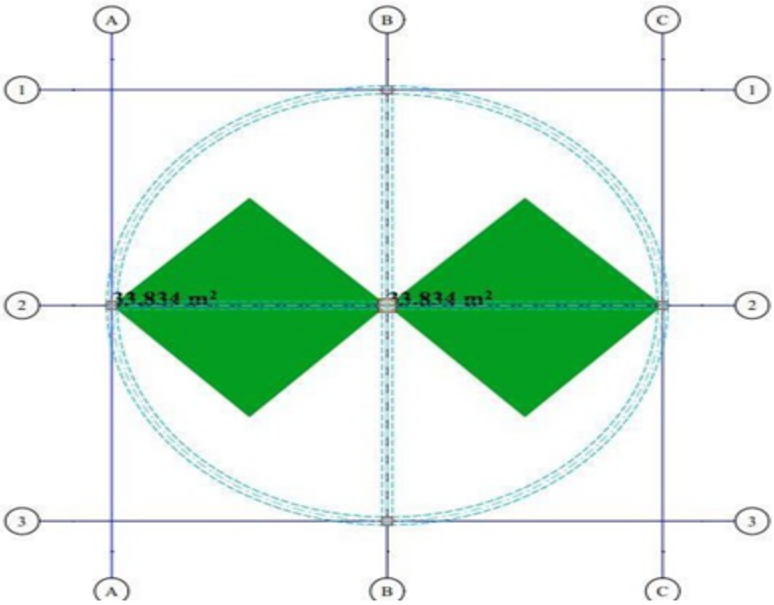


Figure 19.4.critical bean and influence area Load calculation

Design beam 2-2

Span = 8.14mm, A= 33.384mm^2

Weight of slab: 0.25*25*=26.62KN/m

Total finishes: 1.5* = 6.14KN/m

Self -weight of beam: 0.3m*0.3m*25KN/m^3= 2.25KN/m

Total dead load per unit length (GK) = 26.62KN/m+6.14KN/m+2.25KN/m = 35.01KN/m

Live load per unit length: QK* = 2* = 8.19KN/m

Design load (N): 1.4GK+1.6QK

N= 1.4*35.01+ 1.6*8.19= 62.118KN/m

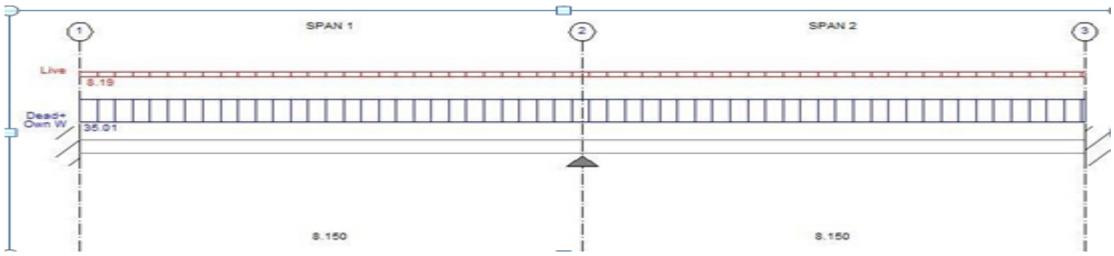


Figure 20.4.beam loaded with dead load and live load (provided by prokon)

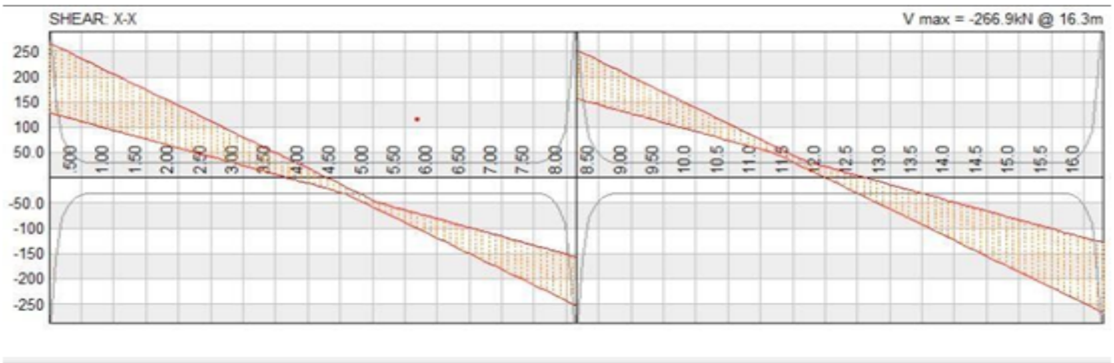


Figure 21.4.shear force diagram (provided by prokon)

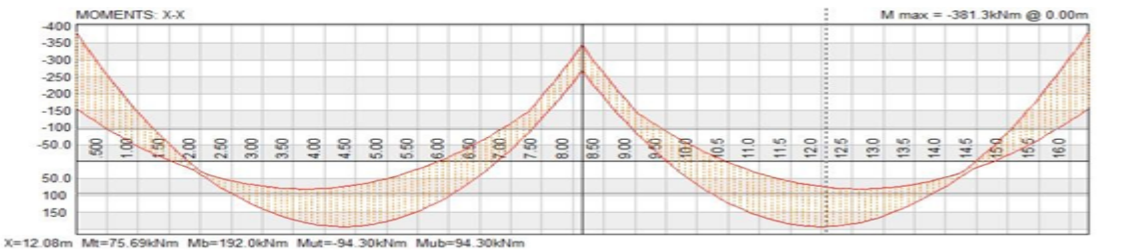


Figure 22.4.bending moment diagram (provided by prokon)

The maximum moment on the supports is **381.3KNm**

Maximum moment at mid-span is **192KNm**

And the maximum shear force is obtained as

266KNDESIGN OF REINFORCEMENTS

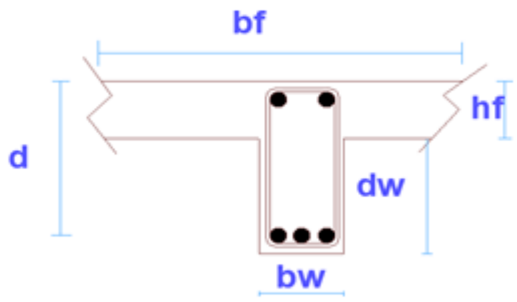


Figure 23.4.cross section of beam

Webh(bw) =

300mmbf = bw +

LZ/ 5

Lz = shortest span x =0.7

Bf=300+ = 1013.125mm

M=192KNm

Dw = 300mm

hf = 250mm

Assuming the main reinforcing bars to be 20mm (∅) and links of 8mm (∅ ′)d= (hf+ dw-cover-Φ/2-θ of link) =250 + 300 − 25 − − 8 = 507*m*m

Moment ultimate

Mu = 0.156fcubd^2, 0.156*30*300*512^2= 368.05KNm

Design moments (M)= = = 515.75KN/m

M>Mu means compression reinforcement required.

Moment of resistance

Mf = 0.45fcu*bw*hf (d-) = 0.45* 30*300*250 (507-) 386.77KNm

Tensile reinforcement

K= = = 0.164> 0.156 Compression reinforcement required.

Area of compression, Assume diameter of compression steel θ=25mm, diameter of links

θ′ = 8mm and cover of reinforcement C is 25mm. Hence effective compression steel d′ is

d′ = C + h′ + θ /2 = 25+8+25/2= 46mm

$As' = ^{=}$ = 848.9mm^2

Provide steel 3T20 As prov= 943mm^2

Area of tension steel: As =

Lever arm = Z = d [0.5 + (]

Z= 507[0.5 + (] = 393.88mm

As = = 2618.15mm^2

Provide 6T25 As prov= 2950mm^2

Tensile reinforcements at the middle

K= = = 0.082 < 0.156, hence No compression reinforcement required

Hence find lever arm using the following formula: Z = d [0.5 + (] ≤0.95d

Z = d[0.5 + (] **= 0.9d**

Then the critical Z is 0.9*512= 460.8mm

A_s =

= = **1126. 88mm2**

As min=0.13% bh =0.13%*300*560 =218.4mm^2< 1126.88mm^2

Provide **4T20** with As pro=1260 mm^2 at the top

Design shear reinforcements

The maximum shear force (V max) =

266KNb=300mm

d=507mm

fyv=250N/mm

2

The shear stress (V) =

= = 1.7

= = 1.9 BS 8110 pt1, clause 3.4.5.6. table 3.8 value of Vc design concrete shear stress, the value of vc (fcu = 25N/mm^2 is 0.78N/mm^2)

Vc = * 0.78 = 0.82N/mm

Vc + 0.4 < V, So =

==055

Provide 8T@175mm (= 0.575)

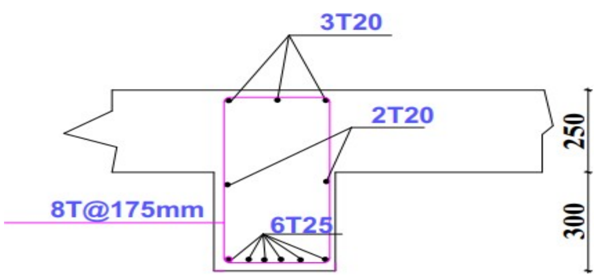


Figure 24.4.Beam details

4.10. DESIGN OF COLUMN

4.10.1. Internal column

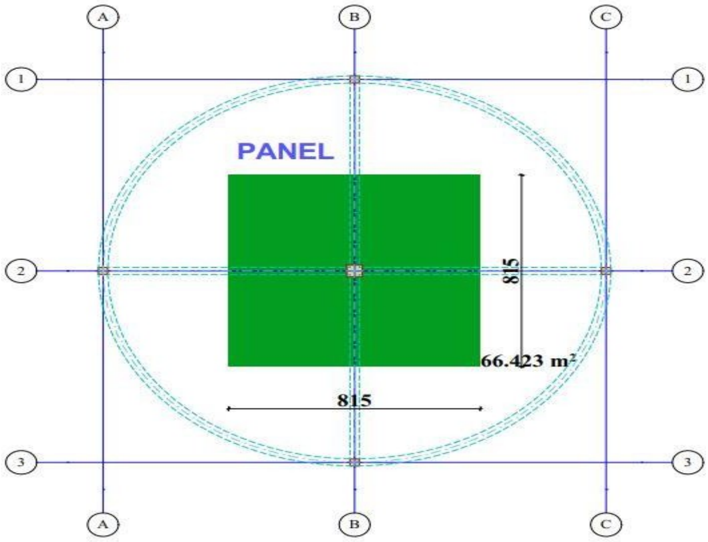


Figure 25.4.Influence area of maximum loaded internal column

Table 5.5.loads acting upon the internal column

No	Unity load (KN/m^2) (KN/m^3)	Unity weight	Volume from the influence zone	Axial loadin KN
2	Slab	25KN/m^3	0.25*8.15*8.15= 16.6m^3	415KN
	T-beam(x)	25KN/m^3	8.15*0.3*0.3=0.734 m^3	18.35KN
	T-beam (y)	25KN/m^3	8.15*0.3*0.3=0.734 m^3	18.35KN
	Column	25KN/m^3	4.8*0.5*0.5=1.2 m^3	30KN
	Finishes	1.5KN/m^2	8.15*8.15=66.42m^2	99.63KN
	Imposed loads (Qk)	2KN/m^2	8.15*8.15=66.42m^2	132.86KN
	TOTAL DEAD LOADS(GK)			**562.98KN**

	design load for N2=1.4Gk+1.6Qk=1.4*562.98KN+1.6*132.86KN=**1000.74KN**			
1	T-beam (y)	25KN/m^3	8.15*0.3*0.3=0.734 m^3	18.35KN
	T-beam(x)	25KN/m^3	8.15*0.3*0.3=0.734 m^3	18.35KN
	Column	25KN/m^3	4.8*0.5*0.5=1.2 m^3	30KN
	TOTAL DEAD LOAD 66.7KN			
	Total load N1= 1.4*GK= 1.4*66.7= **93.38KN**			
	TOTAL LOAD N2-N1= 1000.74+ 93.38= **1094.12KN**			
	Axial loads from column transmitted to the footing			
	Under- ground semicolumn	25KN/m^3	1.7*0.5*0.5= 0.425m^3	10.625KN
	T-beam(x)	25KN/m^3	8.15*0.3*0.3=0.734 m^3	18.35KN
	T-beam(y)	25KN/m^3	8.15*0.3*0.3=0.734 m^3	18.35KN
	Base slab	25KN/m^3	0.25*8.15*8.15= 16.6m^3	415KN
	Finishes	1.5KN/m^2	8.15*8.15=66.42m^2	99.63KN
	Imposed loads (Qk)	2KN/m^2	8.15*8.15=66.42m^2	132.86KN
	Total dead loads = **551.33KN** Design load= 1.4*551.33+1.6*132.86= **984.43KN**			
	Total axial load transmitted in footing= 1094.12KN+ 984.43KN = **2078.55KN**			

Check the slenderness of the column

A braced is said to be short if the ratios, are less than 15 (may fail due to the Compression Failure of the concrete/steel reinforcement) if not they are slender (may fail due to Buckling). For the unbraced if the ratios, are less than 10 the column is said to be short if not it is Slender, Clause 3.8.1.3 and table 3.19) (BS 8110 part 1, 1997)

This column is braced because the lateral loads, due to wind for example, are resisted by shear walls or some other form of bracing rather than by the column.

Since the depth of beam is equal to the depth of column, the value of beta for braced column is 0.75. **Values of beta for braced columns (Table 3.19, BS 8110**

$l_{ex} = l_{o}x * \beta = 4.8 \times 0.75 = 3.6m$ And b=0.5m

$l_{ey} = l_{oy} * \beta = 5.1 \times 0.75 = 3.825m$ And h=0.5m

= = 7.2 and = = 7.65

Therefore, because both 7.2 and 7.65 are less than 10, the column is short braced column

The column moment

This column resists symmetrical arrangements of beams but which are equal in length. There-fore, the column resists axial load only

So, the moments of the column in x direction, and in y direction My will be zero. (S.Unnikrishna Pillai, Devdas Menon, 2003)

Mx′<N*emin where $emin$ = **0. 05h or 20 as the lesser value of eccentricity**.

So, 0KNm< **2078.55KN** *0.05*0.5 = $0KNm < 51.96KNm$as

Mx < N*emin hence let design the column as it is axially loaded.

$N = 0.35fcuAc + 0.67fyAsc$. (**Clause 3.8.4.4, BS8110)**

From the above equation Asc=

Table 6.4.longitudinal reinforcements of column

$N^{\underline{0}}$	Axial load (N)	fy(N/mm^2)	fcu(N/mm^2)	Ac(mm^2)	Asc(mm^2)
2	**1000740**	425	30	250000	-5704.16
1	**1094120**	425	30	250000	-5376.22
Under- ground column	**2078550**	425	30	250000	-1919.05

Because the reinforcements from N2 to underground column are negatives, the standard states that in that case, the reinforcements corresponding to **Asmin**=0.4% **bh** must be provided.

As=**0.4%bh< Asc < 6%bh**, where the longitudinal bars in vertical cast column should be provided from the minimum reinforcement.

As min = = 1000

For N2 provide 6T20 with Asc=1890mm^2
For N1, provide 6T20 with Asc=1890 mm^2

For underground, provide 6T20 with Asc=1890 mm^2

Links design

Size of at least -the largest longitudinal bar but not less than 6mm, which is not actually Available in practice. Take a minimum size of 8mm is preferable.

-* 20 = 5mm, we use the stirrup of **8mm**

The maximum spacing of links is equal 12times the size of smallest longitudinal bar 12*20=240mm, so **provide T8@200mm**

Check for cracking

If the design load on the column (N) is greater than 0.2fcuAc, there is no cracking in the column(**BS 8110 -2: 1985)**

0.2*30*500*500=1500KN, hence N>0.2fcuAc which means

2078.55KN >1500KN **(OK)**, Therefore, there is no cracking in column.

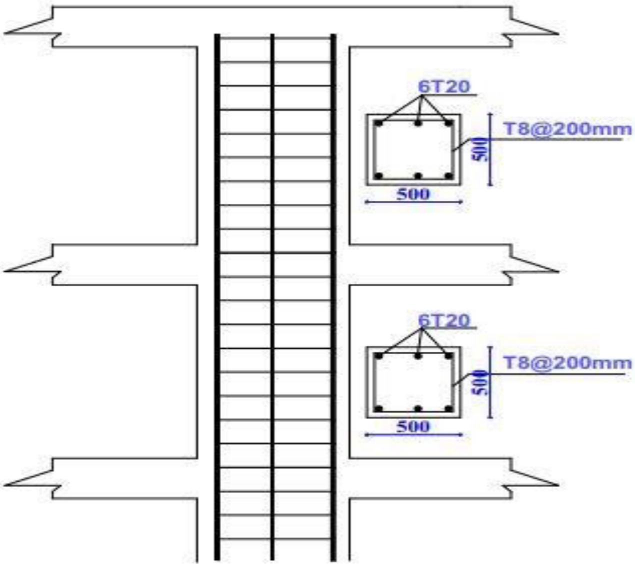


Figure 26.4.Internal column element details

4.10.2. External column

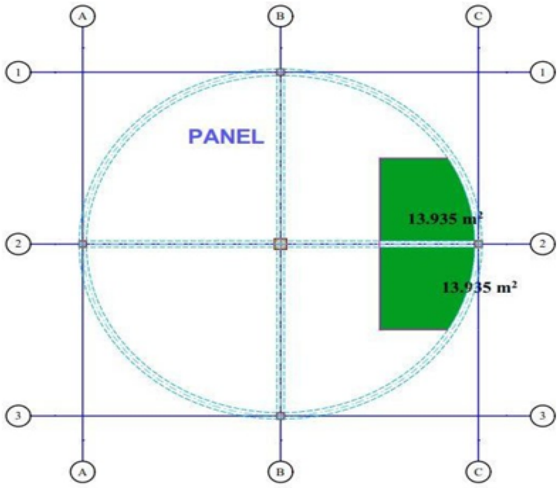


Figure 27.4.Influence area of external column

Table 7.4.loads acting upon the internal column

No	Unity load (KN/m²)(KN/m³)	Unity weight	Volume from the influence zone	Axial loadin KN
2	Slab	25KN/m³	0.25*8.15*4.075= 8.303m³	207.57KN
	beam	25KN/m³	4.075*0.3*0.3=0.367m³	9.17KN
	Column	25KN/m³	4.8*0.3*0.3=0.432m³	10.8KN
	Finishes	1.5KN/m²	8.15*4.075=33.21m²	49.81KN
	Imposed loads (Qk)	2KN/m²	8.15*4.075=33.21m²	66.42KN
	RCC wall	25KN/m³	4.075*0.35*4.8= 6.846m³	171.15KN
	TOTAL DEAD LOADS(GK)			448.5KN
	design load for N2=1.4Gk+1.6Qk=1.4*448.5KN+1.6*66.42KN=734.172KN			
1	beam	25KN/m³	4.075*0.3*0.3=0.367m³	9.17KN
	Column	25KN/m³	4.8*0.3*0.3=0.432m³	10.8KN
	RCC wall	25KN/m³	4.075*0.35*4.8= 6.846m³	171.15KN
	TOTAL DEAD LOAD 191.12KN			
	Total load N1= 1.4*GK= 1.4*191.12= 267.568KN			
	TOTAL LOAD N2-N1= 734.172+ 267.568= 1001.74KN			
	Axial loads from column transmitted to the footing			
	Under- ground semicolumn	25KN/m³	1.7*0.3*0.3= 0.153m³	3.825KN
	beam	25KN/m³	4.075*0.3*0.3=0.367m³	9.17KN
	Base slab	25KN/m³	0.25*8.15*4.075= 8.303m³	207.57KN
	Finishes	1.5KN/m²	8.15*4.075=33.21m²	49.81KN
	Imposed loads (Qk)	2KN/m²	8.15*4.075=33.21m²	66.42KN
	Total dead loads = 270.375KN Design load= 1.4*270.375+1.6*66.42= 484.797KN			
	Total axial load transmitted in footing= 1001.74KN+ 484.797KN = 1486.537KN			

Check the slenderness of the column

A braced is said to be short if the ratios , , are less than 15 (may fail due to the Compression Failure of the concrete/steel reinforcement) if not they are slender (may fail due to Buckling).

For the unbraced if the ratios , , are less than 10 the column is said to be short if not it is Slender, Clause 3.8.1.3 and table 3.19) (BS 8110 part 1, 1997)

This column is braced because the lateral loads, due to wind for example, are resisted by shearwalls or some other form of bracing rather than by the column.

Since the depth of beam is equal to the depth of column, the value of beta for braced columnis 0.75. **Values of beta for braced columns (Table 3.19, BS 8110**

$l_{ex} = l_o x * \beta = 4.8 \times 0.75 = 3.6m$ And b=0.3m

$l_{ey} = l_{oy} * \beta = 5.1 \times 0.75 = 3.825m$ And h=0.3m

And = = 12.75

Therefore, because both 12 and 12.75 are less than 15, the column is short braced column

The column moment

This column resists symmetrical arrangements of beams but which are equal in length. Therefore, the column resists axial load only

So, the moments of the column in x direction, and in y direction My will be zero. (S.Unnikrishna Pillai, Devdas Menon, 2003)

Mx'<N*emin where $emin$ = **0. 05h or 20 as the lesser value of eccentricity**.

So, 0KNm< **1486.537KN** *0.05*0.3 = 0KNm < 22.29KNmas

Mx < N*emin hence let design the column as it is axially loaded.

$N = 0.35 f cuAc + 0.67 f yAsc$. (**Clause 3.8.4.4, BS8110)**

From the above equation

Asc =

Table 8.4.longitudinal reinforcements of column

$N^{\underline{0}}$	Axial load (N)	fy(N/mm^2)	fcu(N/mm^2)	Ac(mm^2)	Asc(mm^2)
2	734172	425	30	90000	-740.39
1	1001740	425	30	90000	199.26
Under- ground column	1486537	425	30	90000	1901.79

Because the reinforcements from N2 are negatives, the standard states that in that case, the reinforcements corresponding to **Asmin**=0.4% bh must be provided.

As**=0.4%bh< Asc < 6%bh**, where the longitudinal bars in vertical cast column should be provided from the minimum reinforcement.

As min = = 360mm^2

For N2 provide 6T12 with A_{SC}= 679mm^2

For N1, provide 6T12 with A_{SC}=679 mm^2

For underground, provide 6T12with A_{SC}=679 mm^2

Links design

Size of at least -of the largest longitudinal bar but not less than 6mm, which is not actually Available in practice. Take a minimum size of 8mm is preferable.

*12 = 3mm, we use the stirrup of **8mm**

The maximum spacing of links is equal 12times the size of smallest longitudinal bar

12*12=144mm, so **provide T8@150mm**

Check for cracking

If the design load on the column (N) is greater than 0.2fcuAc, there is no cracking in the column (**BS 8110 -2: 1985)**

0.2*30*300*300=540KN, hence N>0.2fcuAc which means 148.6537KN >540KN **(OK)**

Therefore, there is no cracking in column.

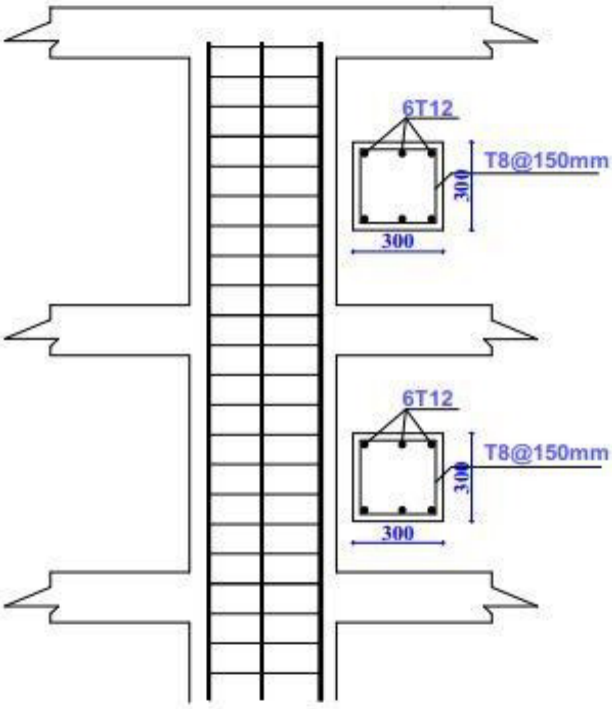


Figure 28.4.External column details

4.11 DESIGN OF FOOTING

Clause 3.3.1.4 in BS of the code states that the minimum cover should be 75 mm if the concreteis cast directly against the earth but if blinding concrete is provided cover should be 50 mm and the minimum grade of concrete to be used in foundations is grade 35.

The following data have been used during the design:

- Concrete cover: 50mm
- Column (500*500) mm
- The compressive strength (fcu) is 35N/mm^2
- fy *is* 450 N/mm^2
- Bearing pressure of the soil is 200KN/m2
- Total dead load from top to the foundation = 1181.01*KN*
- The total live load from top to the foundation =265.72*KN*
- The ultimate axial load on the footing is **2078.55KN**

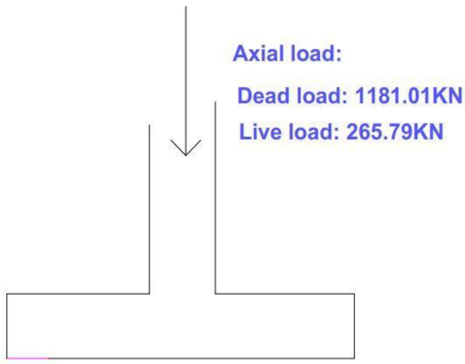


Figure 29.4.loaded column Calculation the loadings

- Computation of the plan area of the footing:
- Service loads GK+ QK: 1181.01KN+265.72KN = 1446.73KN
- The self-weight of the footing range between 10-15% of the service loads
- Let Self-weight of the footing 10% of total weight =1446.73KN *10%=144.67KN
- Total dead load = 1446.73KN +144.67KN = 1591.4KN

Plan area of footing=

= =$8m^2$

h = b = √8 =2.82≈3mm

Self-weight of footing

- 117.603KN=3*3*h*25↔h=0.523m

Let's the overall depth of footing (h) =600mm

- Self-weight of footing=area*h*Unity weight of concrete=8*0.6*25=120KN<assumed self-weight= (144.67KN) (OK)

Bending reinforcements

Design moment

Total ultimate load (W) = 1.4Gk+1.6Qk=1.4*1181.01+1.6*265.72*KN*=**2078.56KN**

Earth pressure (Ps) = = = $230Kn/m^2$

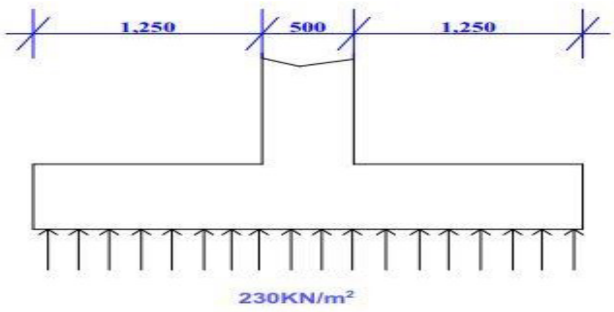


Figure 30.size of footing

Maximum design moment occurs at face of column (M) = = = 180KNm/m

Width slab

Ultimate momentEffective depth

Let's assume the 20 mm diameter bars will be needed as bending reinforcement in both directions

Hence, average effective depth of reinforcement, d is

$d=h-c-\phi=600-50-20=530$ mm

Ultimate moment

$M_u=0.156f_{cu}bd^2=0.156*35*1000*530^2=1533.7$KNm

Since M_u >M means no compression reinforcement required.

K= = 0.018 <0.156, hence no compression reinforcement is required

Z = d [0.5 + (] ≤ $0.95d$

Z = 530[0.5 + (] = $0.97d$ >0.95d

Let's Take Z= $0.95d$=0.95 $*$ 530 =503.5mm

As = = = $913.14 mm2/m$

Minimum steel area is = 0.13%bh = 0.13%*1000*600= 780mm^2/m

Since $A_{s\,min} < A_s$ **(OK)**

Provide T20@300mm c/c (Aprov= 1050mm^2/m)

Distributed uniformly across the full width of the footing parallel to the x-x and y-y axis (see clause 3.11.3.2, BS 8110)

Critical shear stress

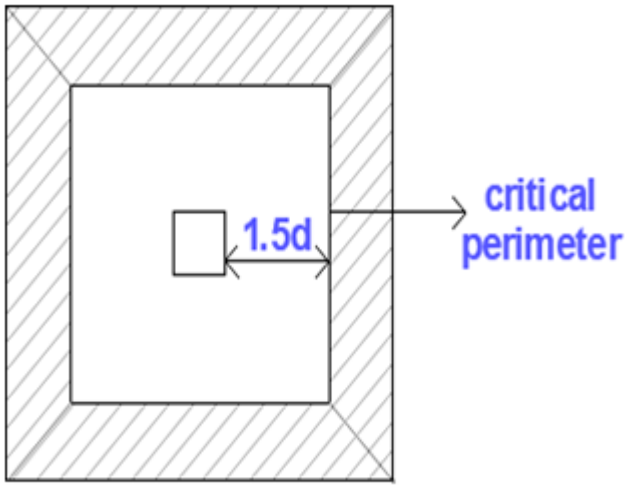


Figure 31.4.punching shear

Critical perimeter P_{crit} =column perimeter

+8*1.5d4*500+8*1.5*530=6360mm

Area within perimeter = $(500+3d)^2$= $(500+3*530)^2$=4.3$m2$

Ultimate punching force, V=load on shaded area=230*(9-4.3) =1081KN

Design punching shear stress V == = 0.32N/$mm2$

Y1=y0 + (y2-y0)

= 0.198, by interpolation =

By interpolation Vc =0.37

Vc = ()$^{1/3}$*0.37 = 0.41

Since Vc >V, punching failure is unlikely and 600mm depth of slab is acceptable.

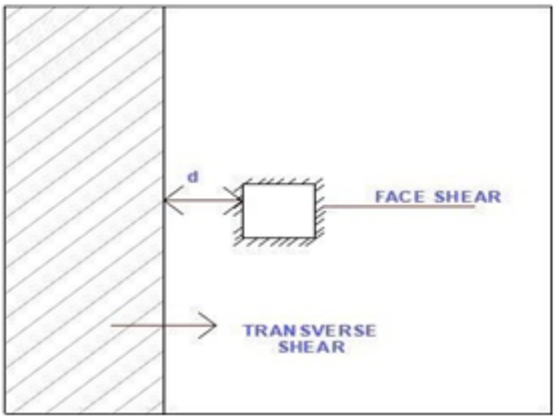


Figure 32.4.face shear

Maximum shear stress (V max) occurs at column

V max = = **=** 1.96mm^2 <permissible (0.8$\sqrt{35}$=4.73 Nmm^2**) OK**

Transverse shear

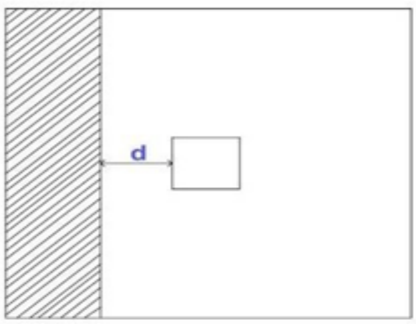


Figure 33.4.transverse shear

Ultimate shear force (V) = load on shaded area = Ps*area =230(3*0.7) =483KNDesign shear stress V

V= = = **0.03Nmm^2** < ***υc***=0.465 **N (OK)** Hence, no shear reinforcement is required

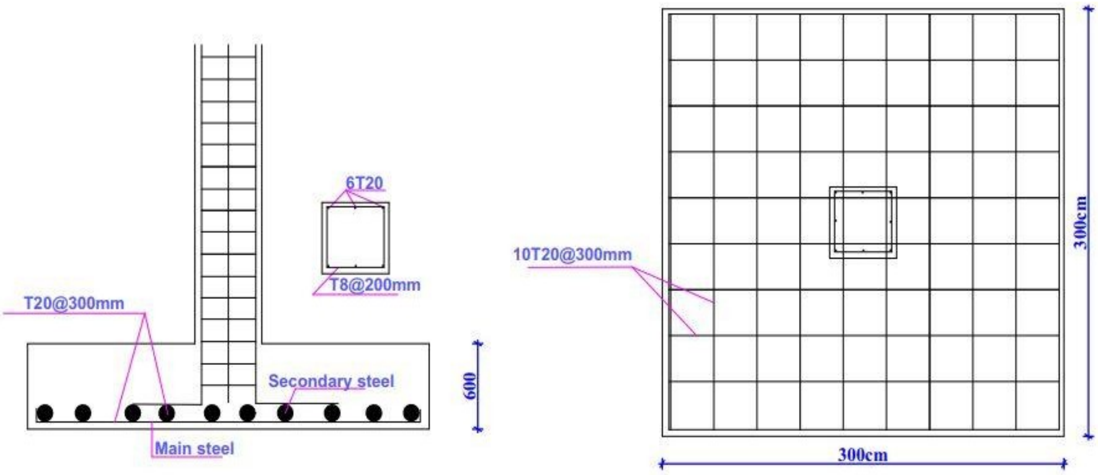


Figure 34.footing element details

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

The objective of the project "Design of reinforced concrete water storage tank" was to determine the requirement of water storage tank, to describe water storage tank capacity to make economic analysis for water storage tank and to design a water storage tank, according to that aim the old water storage tank in BUSASAMANA Sector will be reduced or eliminated. Generally, the project has been achieved the specified objectives. The design of reinforced concrete water storage tanks for drinking and washing purposes tanks are gaining increasingimportance in the present-day life.

According to this, it is better to design the reinforced concrete water storage tank in order to reduce the water storage tank in BUSASAMANA Sector.

5.2. RECOMMENDATION

After the completion of this project, many problems and challenges were encountered. That is why we would like to suggest the following recommendations for those who will implement this project that:

- To respect the structural design details provided for each member
- Provision of soil test must be required
- This overall project will help those who will be interested in using it especially next students who will perform their projects in the same field.
- We recommend also ULK Polytechnic libraries do not have necessary books for civil engineering this may be corrected as soon as possible to facilitates the under taken students of next year.
- Poor internet present in ULK Polytechnic leads to fail the achievement of some objectives such as internet research. And also, to increase time of project preparation.

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APPENDIX

APPENDIX 1: CASE STUDY DESCRIPTION

A map of BUSASAMANA Sector in NYANZA district which shows slope of plot where the rein-forced concrete water storage tank will be constructed.

Figure: Slope of Plot (Image from google Map)

Cross-sectional areas of groups of bars (mm²)

Bar size (mm)	Number of bars									
	1	2	3	4	5	6	7	8	9	10
6	28.3	56.6	84.9	113	142	170	198	226	255	283
8	50.3	101	151	201	252	302	352	402	453	503
10	78.5	157	236	314	393	471	550	628	707	785
12	113	226	339	452	566	679	792	905	1020	1130
16	201	402	603	804	1010	1210	1410	1610	1810	2010
20	314	628	943	1260	1570	1890	2200	2510	2830	3140
25	491	982	1470	1960	2450	2950	3440	3930	4420	4910
32	804	1610	2410	3220	4020	4830	5630	6430	7240	8040
40	1260	2510	3770	5030	6280	7540	8800	10100	11300	12600

APPENDIX 2: TABLE USED IN DESIGN

Table 1: Cross-sectional areas of groups of bars (mm2)

Table 3.22 Cross-sectional area per metre width for various bar spacing (mm²)

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

Table 2. Cross-section area per meter width for various bar spacing (mm2)

Stirrup diameter (mm)	Stirrup spacing (mm)										
	85	90	100	125	150	175	200	225	250	275	300
8	1.183	1.118	1.006	0.805	0.671	0.575	0.503	0.447	0.402	0.366	0.335
10	1.847	1.744	1.57	1.256	1.047	0.897	0.785	0.698	0.628	0.571	0.523
12	2.659	2.511	2.26	1.808	1.507	1.291	1.13	1.004	0.904	0.822	0.753
16	4.729	4.467	4.02	3.216	2.68	2.297	2.01	1.787	1.608	1.462	1.34

Table 3. Asv/Sv for varying stirrup diameter and spacing

$\frac{100A_s}{bd}$	*Effective depth (d) mm*							
	125	*150*	*175*	*200*	*225*	*250*	*300*	*≥ 400*
≤ 0.15	0.45	0.43	0.41	0.40	0.39	0.38	0.36	0.34
0.25	0.53	0.51	0.49	0.47	0.46	0.45	0.43	0.40
0.50	0.57	0.64	0.62	0.60	0.58	0.56	0.54	0.50
0.75	0.77	0.73	0.71	0.68	0.66	0.65	0.62	0.57
1.00	0.84	0.81	0.78	0.75	0.73	0.71	0.68	0.63
1.50	0.97	0.92	0.89	0.86	0.83	0.81	0.78	0.72
2.00	1.06	1.02	0.98	0.95	0.92	0.89	0.86	0.80
≥ 3.00	1.22	1.16	1.12	1.08	1.05	1.02	0.98	0.91

Table 4. Values of *vc* design concrete shear stress (From BS8110:1985)

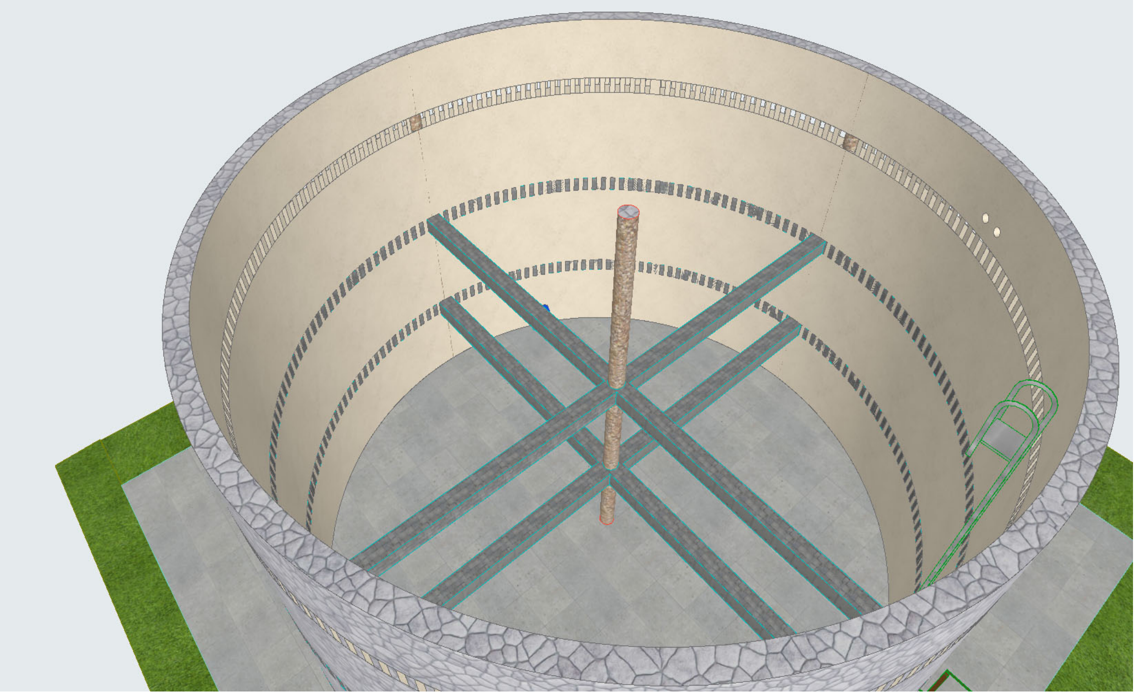
APPENDIX 3: BUDGET OF PROJECT AND PROJECT SCHEDULEPROJECT SCHEDULE

Activities	March				May				June				July				August				September				October			
Weeks	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Topic selection& visit site																												
Preparation of project proposal& submission																												
literature reviewand methodology preparing																												
Design of Reinforced water storage tank																												
Submission of Project report																												
Final project Defense																												

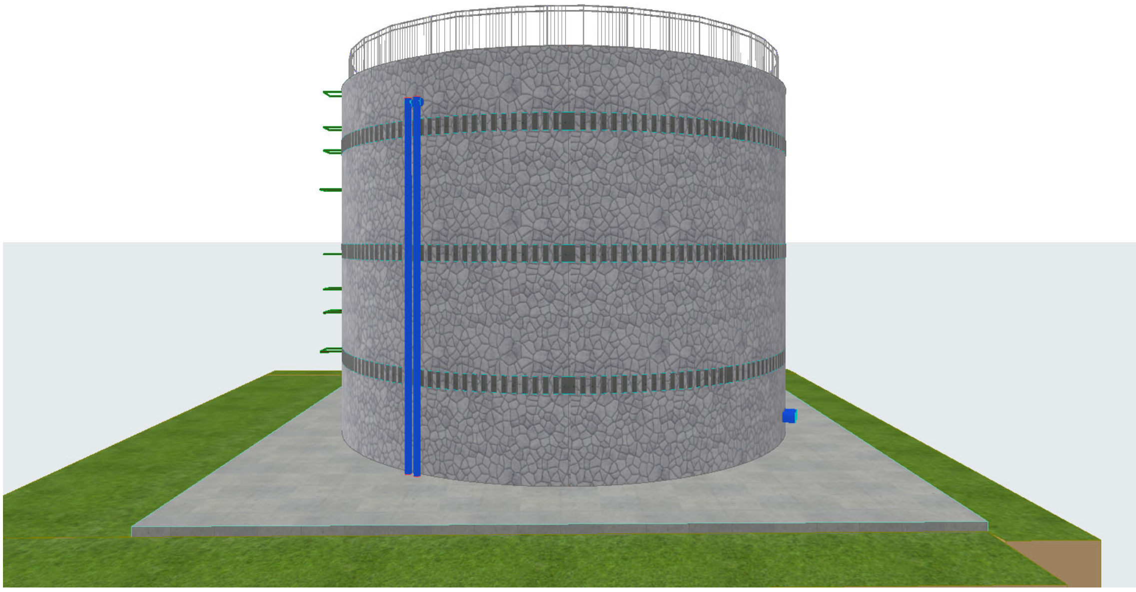
PROJECT BUDGET

N^O	ITEMS	AMOUNT (Rwf)
1	**Project proposal**	
	Internet	10,000
	Printing	5,000
	Covering	1,000
	Site visit (Transport)	30,000
	Preparation for the study	30,000
2	**Project report**	
	Internet	30,000
	Printing	10,000
	Cover	3,000
TOTAL		**119,000 Rwf**

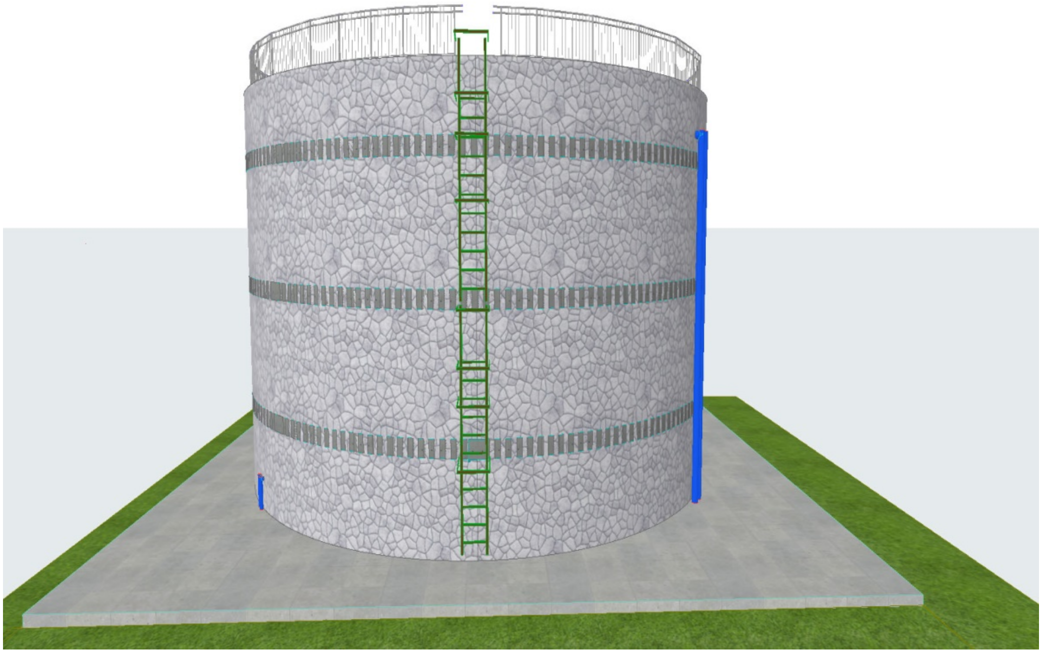
APPENDIX 4. PLAN VIEW, ELEVATION, SECTION AND PERSPECTIVE



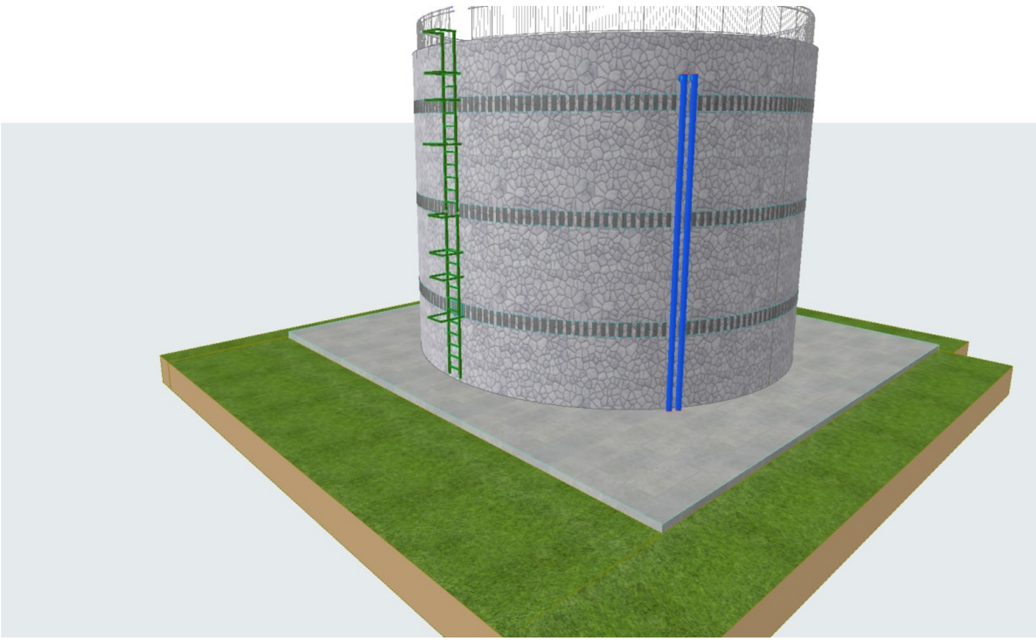
Side view



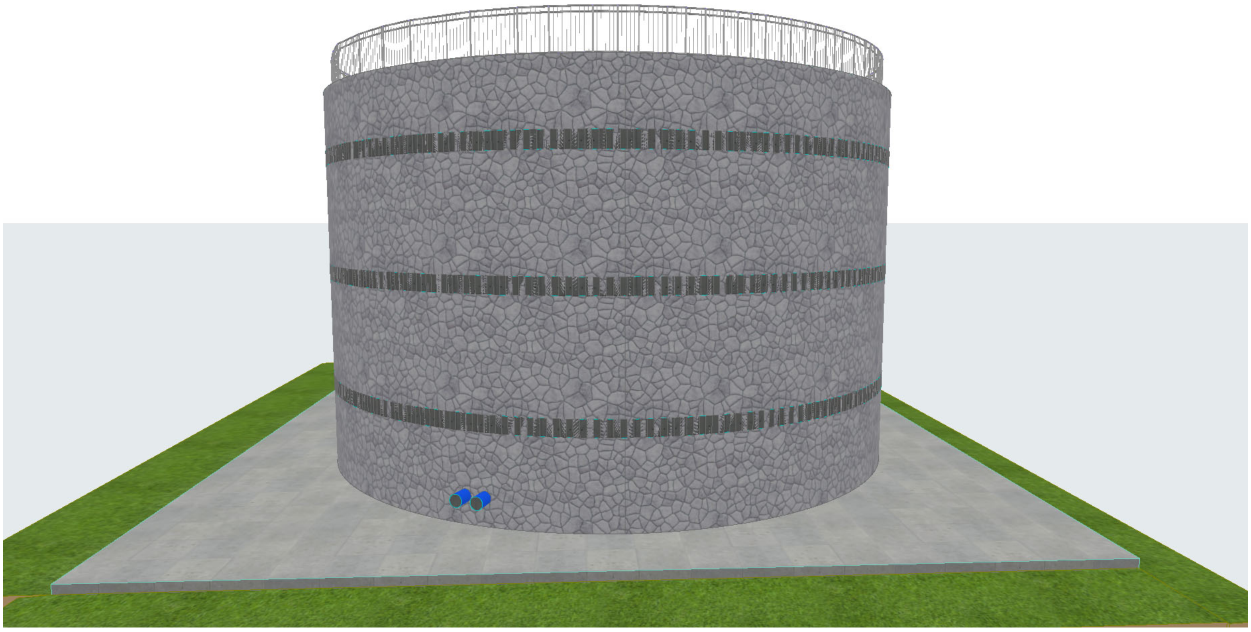
Right View



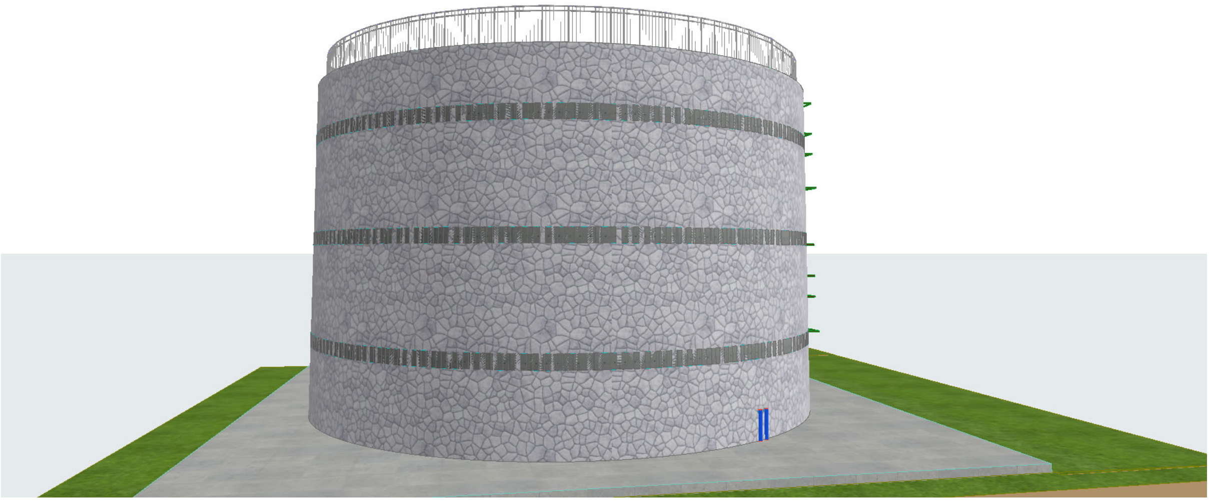
Front view



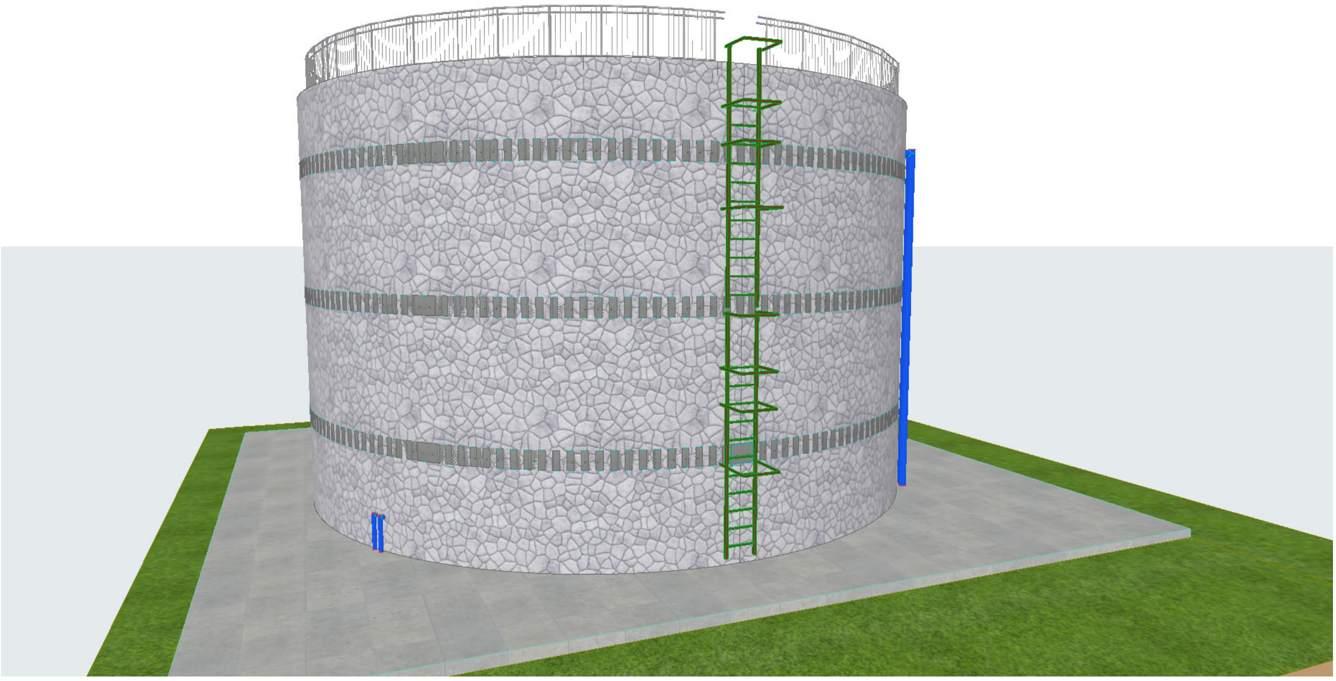
Elevation



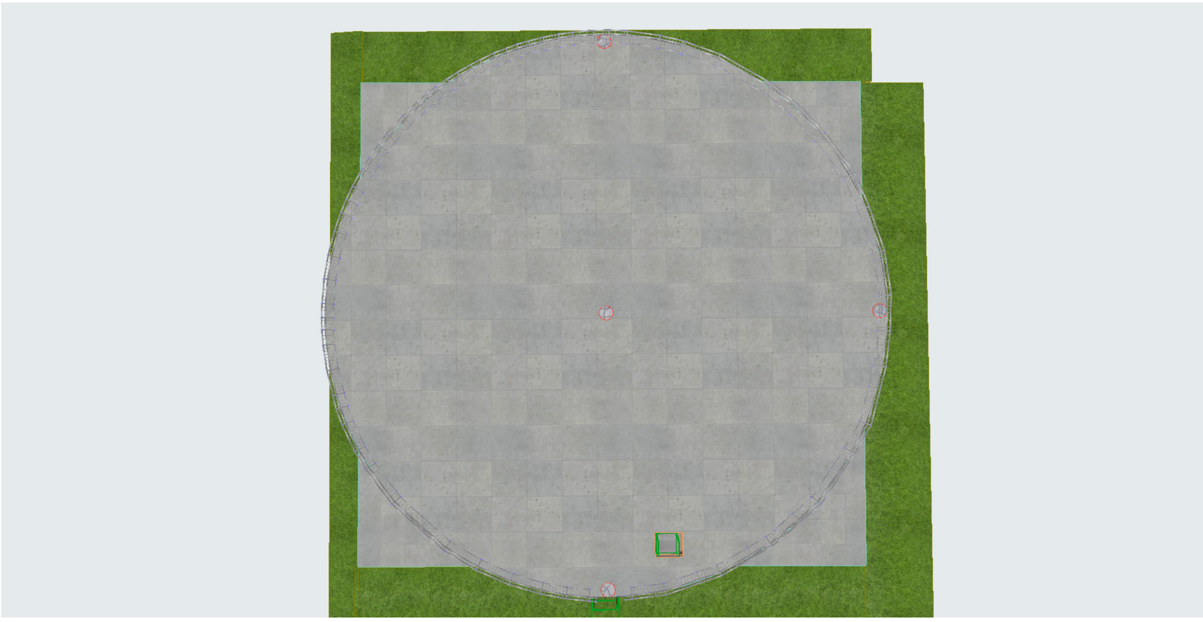
Back view



Left view



3 d view



Top view