DESIGN OF A RAIN WATER HARVESTING SYSTEM AT FACULTY OF ENGINEERING, TECHNOLOGY, APPLIED ART AND DESIGN, KABALE UNIVERSITY

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BY

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AN ENGINEERING PROJECT REPORT SUBMITTED TO THE FACULTY OF ENGINEERING, TECHNOLOGY, APPLIED DESIGN AND FINE ART KABALE UNIVERSITY (KAB) IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF CIVIL ENGINEERING

JANUARY, 2021

DECLARATION

I gladly declare that; I am the sole writer of this report and it has never been submitted to any institution of higher learning for the award of a degree or any other academic award.

Student's name: NYANZI IBRAHIM
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Sign:

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APPROVAL

This is to certify that this study has been carried out under my supervision and has been submitted for examination with my approval as the University supervisor.

Signature: Date:

Mr. Tibenderana **Philip**

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DEDICATION

With great love, I dedicate this project to Kabale University, faculty of engineering, applied art and design as a solution to the intermittent water supply from the main water supply by National water and sewerage corporation in addition to high water bills.

ACKNOWLEDGMENT

Firstly, I would like to thank the Almighty God for his endless protection and blessings he has bestowed to me throughout my life. I also thank him for granting me the opportunity to be in school and granting me the ability to take on this project design successfully.

Secondly i would like to express my utmost gratitude thanks to my parents for the support (more especially in terms of finance) they have provided me till completion of this project.

Thirdly, i greatly thank my University Supervisor, Mr. Tibenderana Phillip for the great knowledge, guidance, encouragement, advise, different ideas, and suggestions he provided me with till the completion of my project and preparation of this report..

Also, I thank the Kabale University fraternity for providing students with such a great opportunity to practically apply the theoratical studies

Finally, I thank everyone who rendered any help to me during the design period of my project till its completion, may God bless you abundantly

ABSTRACT

Rain water harvesting is a technology used to collect,convey and storing rain water for later use from relatively clean surface such as roofs,the land surface or rock catchments.

This project aimed at designing a Rain water harvesting system at Kabale Univeristy,Faculty of Engineering as the solution to overcome the problem of the intermittent water supply from the main water supply by National water and sewerage corporation in addition to high water bills at the Faculty.

The methods used in this project include Reconnaissance surveying (site attending) aimed at determining rainwater harvesting components available within the area of study eg.roof material and capturing the water demand at the faculty ,Data collection and analysis ie rainfall data captured from kabale district Meteological department.and finally designing the rainwater harvesting system after having all the necessary data at hand.

The design involved calculations of the catchment areas, sizing of the gutters and downpipes per each catchment area and finally sizing of an optimum storage tank where all the water captured from the catchment area was to be stored for institutional use.

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CHAPTER ONE: INTRODUCTION

Rain water harvesting is a technology used to collect,convey and store rain water for later use from relatively clean surface such as roofs,the land surface or rock catchments. The main objective of our project was to design a Rain water harvesting system at Kabale University, Faculty of Engineering, Applied Art and Design as a solution to overcome the problem of increased water demand(i.e due to the construction of a waterborne toilet) and running costs of the existing water supply system(National water and sewerage corporation).

1.1 Background Information

Nyabikoni Campus had its main water supply as National Water and Sewerage Corporation line together with a simple mini rainwater harvesting system. This, in essence, caused a significant increase in running costs(budgets) due to the daily water usage throughout all campus activities.

1.2 Problem Statement

The Faculty of Engineering, Technology, Applied Design and Fine Art, Nyabikoni Campus suffers from intermittent water supply from the main water supply by National water and sewerage corporation in addition to high water bills. This has resulted increased water shortages to run the daily activities, regardless of the presence of sufficient roof catchment and adequate rainfall, less efforts have been made to harvest rainwater to supplement this unreliable water Supply

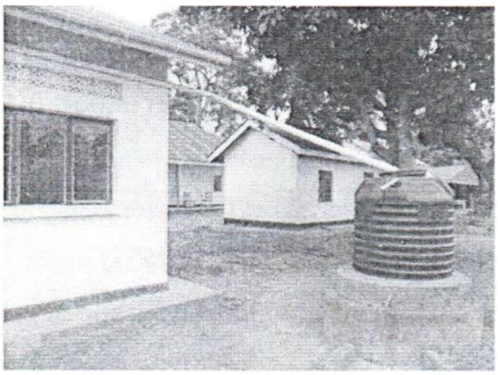

Figure 2: Existing 1000 litres mini Rainwater Harvest System

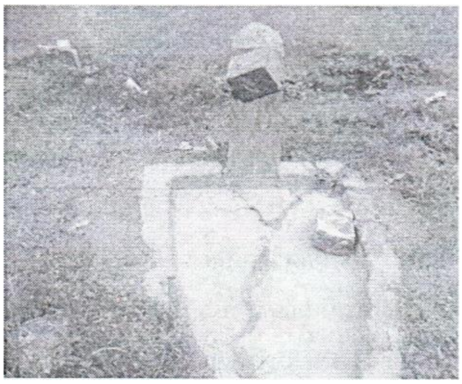

Figure 1: Existing National Water and Sewerage Corporation line

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1.3 General Objectives

The main objective of this project was to design a rain water harvesting system for Nyabikoni Campus as the solution to overcome the problem of increased water demands and running cost of water supply system.

1.4 Specific Objectives

As per the project these were the specific objectives leading to the main objective stated above;

1) Site reconnaissance survey
2) To analyze the rainwater data and patterns
3) To determine the demand of water at Nyabikoni campus
4) To design a rainwater harvesting system

1.5 Significance of the Project

The significance of this project was to solve the problem of increased water demand and running costs with regards to the existing water supplies through proper utilisation of rainfall within the catchment areas present via collection (use of catchment areas i.e roofs), conveying (use of gutters and downpipes) and storing it (storage tank) for later use, thus boosting the existing water resources.

The project aslo aimed at creating an alterantive water supply incase of failure of the existing water supplies

1.6 Scope of the Study

The design of rainwater harvesting system covered the whole area i.e. the catchiment area put into consideration all the seven buildings(with deferent roof dimensions). By considering the measurements and calculations of the catchiment areas and the average annual rainfall, this helped to provide the possible amount of water to be collected from all the buildings and finally helped in determining the adequate storage tank to avoid issuses of overflow. These calculations also helped in designing gutters and down pipes per the seven buildings

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CHAPTER TWO: LITERATURE REVIEW

Most of people collect and store rainwater in buckets, tanks, ponds and wells. This is commonly referred to as rainwater harvesting and has been practiced for centuries. Rainwater can be used for multiple purposes ranging from irrigating crops to washing, cooking and drinking

The design of rainwater harvesting system is a simple and low-cost technique that requires minimum specific expertise or knowledge and offers many benefits. Collected rainwater can supplement other water sources when they become scarce and low quality like brackish groundwater or polluted surface water in the rainy season.

The design of rainwater harvesting system in phillipines was implemented as a part of the income generating activities in Capiz province.The philipines use this rainwater harvesting for agricultural and pastoralism purpose which provide an income generating opportunities that could provide sufficient income to repay the loans that was assisted by Canada. (Gould, 1992)

Also the history of rainwater harvesting in Asia can be traced back to about the 9th or 10th Century and the small-scale collection of rainwater from roofs and simple brush darn constructions in the rural areas of South and South-east Asia. Rainwater collection from the eaves of roofs or via simple gutters into traditional jars and pots has been traced back almost 2000 years in Thailand (Prempridi and Chatuthasry, 1982). Rainwater harvesting has long been used in the Loess Plateau regions of China. More recently, however, about 40,000 well storage tanks, in a variety of different forms, were constructed between 1970 and 1974 using a technology which stores rainwater and storm water runoff in ponds of various sizes.

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Table I :Run off coefficient of different surfaces.

SURFACE	RUN-OFF COEFFICIENT
I. Roof catchments	
– Roof tiles Corrugated	0.8 to 0.9
sheets	0.7 to 0.9
2. Ground surface covering	0.6 to 0.8
– Concreted	0.8 to 0.9
Bitumen, plastic sheeting, butyl rubber Brick	0.5 to 0.6
pavement	
3. Compacted and smoothened soil	0.3 to 0.5
4. Treated ground catchments	
– Clay/ cow dung trashing floors	0.5 to 0.6
Silicone treated soil	0.5 to 0.8
Soil treated with sodium salts Soil	0.4 to 0.7
treated with paraffin wax	0.6 to 0.9
5. - Uncovered surface, flat terrain	
– Uncovered surface, slope less than l 0%	0.3
– Rocky natural catchments	0.0 to 0.4
	0.2 to 0.5

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Table 2: Catchment type and effect on Water quality.

Type	**Effect on water quality**
GI Sheets and aluminium	• Excellent water quality • Surface is smooth and high temperatures help to sterilise the water (kill bacteria)
Tiles (glazed)	• Good water quality Unglazed tiles can harbour mould Contamination can exist in tile joins.
Asbestos-cement sheets	• New sheets give good quality water • No evidence of carcinogenic effects from ingestion • Slightly porous so reduced run-off coefficient • Older roofs harbour moulds and even moss

2.1 System Components and Design Considerations 2

.1.1 Basic Components of Rain Water Harvesting

Each rainwater harvesting system consists of three basic components (Nissen-Peterson, 2015)

1. **Catchment or roof surface** to collect rainwater
2. **Delivery system** to transport the water from the roof to the storage reservoir (gutters and drainpipes)

3. **Storage reservoir or tank** to store the water until it is used. The storage reservoir has an extraction device that- depending on the location of the tank may be a tap, rope and bucket, or a pump.
4. **Water Treatment:** filters and equipment, and additives to settle, filter, and disinfect.
5. **Catchment surface:** The catchment of a water harvesting system is the surface that receives rainfall directly and drains the water to the system. This Agrodok focuses on rooftop R WH, but surface run-off RWH is also possible. Surface water is, however, in most cases not suitable for drinking purposes since the water quality is not good enough. Any roofing material is acceptable for collecting water. However, water to be used for drinking should not be collected from thatched roofs or roofs covered with asphalt. Also lead should not be used in these systems. Galvanized, corrugated iron sheets, corrugated plastic and tiles make good roof catchment surfaces. Flat cement or felt-covered roof can also be used provided they are clean. Undamaged asbestos- cement sheets do not have a negative effect on the water quality. Small damages may, however, cause health problems.
6. **Delivery system:** The delivery system from the rooftop catchment usually consists of gutters hanging from the sides of the roof sloping towards a downpipe and tank. This delivery system or guttering is used to transport the rainwater from the roof to the storage reservoir. For the effective operation of a rainwater harvesting system, a well-designed and carefully constructed gutter system is crucial because the guttering is often the weakest link in a rainwater harvesting system. As much as 90% or more of the rainwater collected on the roof will be drained to the storage tank if the gutter and downpipe system is properly fitted and maintained. Common material for gutters and downpipes are metal and PVC. With high intensity rains in the tropics, rainwater may shoot over the (conventional) gutter, resulting in rainwater loss and low harvesting production; splash guards can prevent this spillage.
7. **Storage reservoirs:** The water storage tank usually represents the biggest capital investment element of a domestic **R WH** system. It therefore usually requires the most careful design- to provide optimal storage capacity and structural strength while keeping the costs as low as possible. Common vessels used for very small-scale water storage in developing countries include plastic bowls and buckets,jerry cans, clay or ceramic jars, old oil drums or empty food containers.

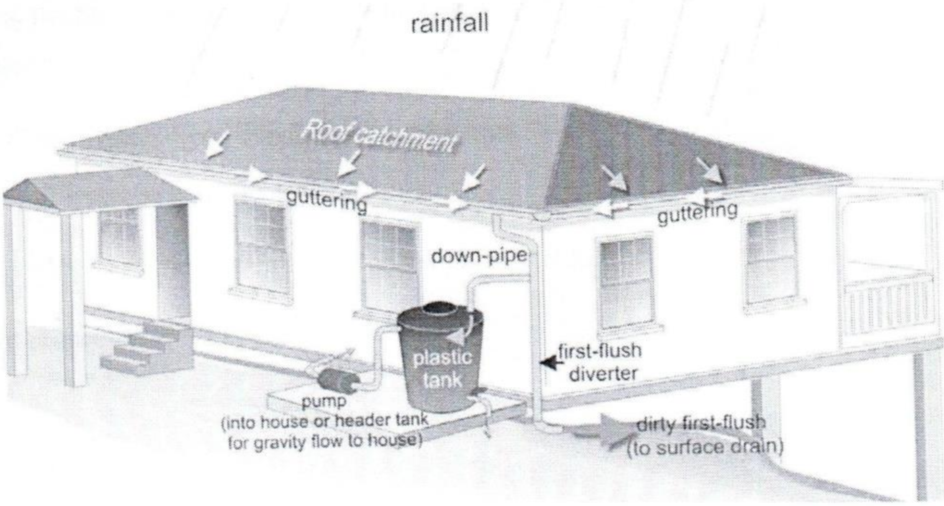

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Figure 3: Rainwater Harvesting Components

2.1.2 Design Considerations for Rooftop Catchment Systems

The material of the catchment surfaces must be non-toxic and not contain substances which impair water quality.

Roof surfaces should be smooth, hard and dense since they are easy to clean and are less likely to be damaged and shed materials into water

Precautions are required to prevent the entry of contaminants into the storage tanks.

- No overhanging tree should be left near the roof
- The nesting of the birds on the roof should be prevented
- A first flush bypass such as detachable downpipe should be installed

All gutter ends should be fitted with a wire mesh screen to keep out leaves, etc.

The storage tank should have a tight-fitting roof that excludes light, a manhole cover and a flushing pipe at the base of the tank.

The design of the tank should allow for thorough scrubbing of the inner walls and floor or tank bottom. A sloped bottom and a provision of a sump and a drain are useful for collection and discharge of settled grit and sediment.

Taps/faucets should be installed at 10 cm above the base of the tank as this allows any debris entering the tank to settle on the bottom where it remains undisturbed, will not affect the quality

of water.

2.1.3 Catchment Area Design Calculations

Volume of water to be collected.

= Mean Annual Raifall x Catchment area x Runoff coefficient

Area of sloped Roof = Length Width

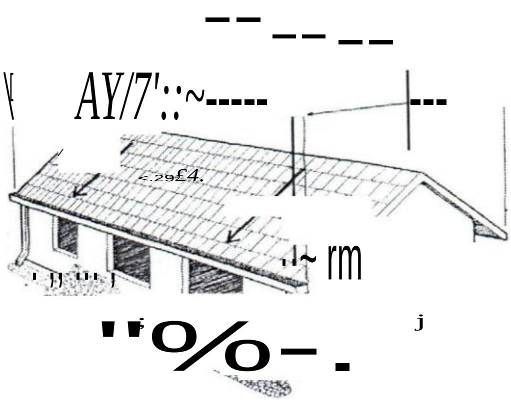

Fig.4 sloped roof

2.1.4. Factors Affecting Rainwater Harvesting System Design

- ✓ Rainfall quantity (mm/year)
- ✓ Rainfall pattern
- ✓ Collection surface area (m^2)
- ✓ Runoff coefficient of collection (-)
- ✓ Storage capacity (m^3)
- ✓ Daily consumption rate (litres/capita /day)
- ✓ Number of users
- ✓ Cost

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2.2 Rainwater Quality And Health

Rainwater is often used for drinking and cooking and so it is vital that the highest possible standards are met. Generally the chemical quality ofrainwater will fall within the WHO guidelines **and** rarely presents problems. There are two main issues when looking at the quality and health aspects of rainwater harvesting.

Firstly, there is the issue of bacteriological water quality. Rainwater can become contaminated by dirties entering the tank from the catchment area. It is advised that the catchment surface always **be** kept clean. Rainwater tanks should be designed to protect the water from contamination by leaves, dust, insects, vermin, and other industrial or agricultural pollutants. Tanks should be sited away from trees, with good fitting lids and kept in good condition. Incoming water should be filtered or screened, or allowed to settle to take out foreign matter. Water which is relatively clean on entry to the tank will usually improve in quality if allowed to sit for some time inside the tank. Bacteria entering the tank will die off rapidly if the water is relatively clean. Algae will grow inside a tank if sufficient sunlight is available for photosynthesis. Keeping a tank dark and sited in a shady spot will prevent algae growth and also keep the water cool. As mentioned in a previous section, there are a number of ways of diverting the dirty 'first flush' water away from the storage tank. The area surrounding a rainwater harvesting should be kept in good sanitary condition, fenced off to prevent animals fouling the area or children playing around the tank. Any pools of water gathering around the tank should be drained and filled. Gould points out that in a study carried out in north east.

Secondly, there is a need to prevent insect vectors from breeding inside the tank. In areas where malaria is present, providing water tanks without any care for preventing insect breeding can cause more problems than it solves. All tanks should be sealed to prevent insects from entering. Mosquito's proof screens should be fitted to all openings. Some practitioners recommend the use of 1 to 2 teaspoons of household kerosene in a tank of water which provides a film to prevent

mosquitoes settling on the water.

There are several simple methods of treatment for water before drinking.

- Boiling water will kill any harmful bacteria which may be present
- Adding chlorine in the right quantity (35ml of sodium hypochlorite per 1000 litres of water) will disinfect the water
- Slow sand filtration will remove any harmful organisms when carried out properly

CHAPTER THREE: METHODOLOGY

This chapter covers the systematic and theoretical analysis of the methods that were applied in the **design** of this project, and include the following;

3. I Reconnaissance Survey

This involved site visits and inspections that were aimed at having an overview of the area of study so as to come up with design finding such as; Catchment area, Water deman, Area rainfall patterns and materials needed (such as gutters, pipes, pipe fitting,filters,clamps,cement,aggregates,BR6 wire mesh,steel bar.), Equipment/tools to be used such as include spade,pick axe,hoe,hammers,screw driver, Tape measure used for measuring distance, String used for setting the gutter slope, Water level, Ladder used for climbing

3 .1.1 Population data

This aimed at determing the current population at the engineering campus plus predicting the future population inorder to aquire the total water demand and daily water consumption ie. Litres per person per day to adequate design the rainwater harvesting system

This involved mathematical calculations considering the following asspects;

Present population (Po)= 334 Students

Future population (Pn) =?

Period (n) = 10 years

Growth rate (r) =5%

And finally punching the resullts in the following equation thus obtaing the future population inorder to appropriately design for the growing population.

$Pn = Po(] + r/100)^{n}$ Pn=

334(1+5/100) ""
Pn = 544 Students

After the population estimations, the next step was determining the water demand using the equation below;

•

Demand= Water Use x **Number of people**

As per this project, water usage per person per day is 70L/day. (obtained from ministry of water **design** manual 2009).

Thus;

Demand= Pn x water use (1/p/day)

= 544x 70L/ day

= 38,080Litres/day

3 .1.2 Rainfall data

This involved visiting the Kabale District Meteorology Station and acquiring information regarding the monthly rainfall data and rainfall patterns for the five previous years which was used to compute the average annual rainfall.

Table 3: Monthly Rainfall data obtained from Kabale District Meteorology Station

YEAR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**TOTAL**
2015	7.7	9.8	124.4	62	117.4	106.9	50.9	15.7	37.2	114.9	140.1	128.5	915.5
2016	94.2	85.8	29.9	94.5	174.3	81.3	32.9	18.8	43.2	163.6	130.2	124.1	1072.8
2017	55.8	41.4	50.l	114.8	71.5	76	4.7	35.5	53.5	120.2	176.4	163.0	962.9
2018	74.1	87.9	114.6	113.0	304.9	95.2	37.9	49.8	73.7	41.6	84.4	41.5	11 l 8.6
2019	151.6	19.0	73.0	87.7	139.8	62.8	107.5	36.5	24.6	95.1	199.6	99.8	1097. l

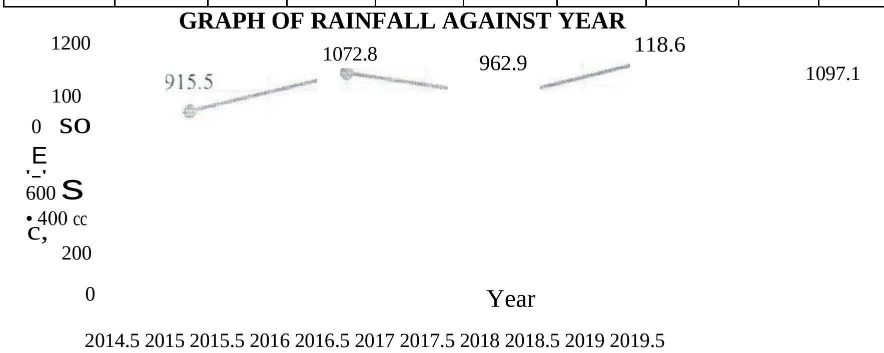


Figure 5: Agraph of Rainfall amount against Year

3 .2 Measurement Data

These involved measuring of the lengh, and width of the roof so as to obtain the roof catchment area which lateron provided the amount of water to be collected from each roof of the seven buildings

Determination of volume of water collected from all roofs within the faculty of engineering and this will involved the use of the following equation;

S=RAX Cr

Supply= Rainfall x **Area** x **Run-off coefficient (Cr)**

Where:

S = Mean annual rainwater supply (m^3)

R = Mean annual rainfall (m) A=

Catchment area (m)

Cr = Run-off coefficient, this equals to 0.9 for roof catchments

Considering the 5 years annual rainfall data as obtained below, Kabale average annual rainfall was calculated as follows;

Table 4: Kabale District Annual Rainfall Data for the previous 5 years

No.	Year	Average annual rainfall
1.	2015	915.5
2.	2016	1072.8
3.	2017	962.9
4.	2018	1118.6
5.	2019	1097.1

Average mean annual rainfall as per the 5 years;

$$\frac{915.5 + 1072.8+962.9+1118.6+1097.1}{5} = \mathbf{1033.38mm}$$

Table 5: Catchment Area Calculations

No.	BUILDING BLOCK	DIMENSIONS		CATCHMENT AREA (m)
		length (m)	width (m)	
1.0	Civil Laboratory	9.25	6.64	61.42
2.0	Civil-Electrical Departments Office	8.26	4.60	38.00
3.0	Library	9.3	6.72	62.50
4.0	Dean's Office	6.63	5.88	38.98
5.0	Computer Lab - Lecture rooms Block	13.45	11.18	150.37
6.0	Staff Room	11.54	4.60	53.08
7.0	New Lecture block	15.5	9.00	139.50
8.0	Art - Department block			163.00
9.0	Electrical-Mechanical workshop			282.87
	TOTAL CATCHMENT AREA			**989.72**

3.2.2 Total volume of water to be harvested

Catchment area = 989.72m

Kabale average annual rainfall = 1033.38mm (1.03338m)

Total annual volume of rainfall over the catchment areas

= catchment area **x** annual rainfall **x** run off co-efficient

= 989.72 X 1.03338 X 0.9

= 920.5m

=920.500_Litres

Assuming that 70% of the total rainfall is efficiently harvested;

Volume of water harvested= 920,500 x 0.7

=**644.350_Litres**

Average water ability per day;= $\frac{644,350}{365}$

= **1765.34 Litres/day**

3 .2.3 Storage Tank Sizing

The size of storage tank was determined after calculating the total catchment area for all the buildings within the faculty of engineering, and the average annual rainfall of the area plus the running coefficient of catchment which provide the total amount of water to be collected thus choosing an appropriate storage tank size.

Tank sizing is important in determining the optimum capacity of a tank for a particular water demand, catchment area and amount of rainfall available.

When a tank is sized correctly, it avoids wastage of materials in building a tank that is too large and will never fill, or building a tank that is too small and always overflows. A right size capacity of tank should provide enough water throughout the dry season.

The critical design parameters for tanks are;

1 Rainfall data (mm) 1

Catchment area (m°)

Storage Tank Designs;

- ✓ Average Annual Rainfall = 1033.38mm/yr
- ✓ Catchment Area = 989.72mm
- ✓ Total annual volume of rainfall over the catchment areas =

  catchment area **x** annual rainfall **x** run off co-efficient

  = 989.72 **X** 1.03338 X 0.9 = 920.5m°

  = 920,500 Litres

✓ **Optimum storage tank capacity**= $\frac{1}{3}$ Total annual volume of rainfall

$$= \frac{1}{3}(920,500)$$

$$= \textbf{306833.33 Litres}$$

Considering the issues of overflow the optimum storage tank capacity is taken as **350,000Litres** underground storage tank

3.2.4.Storage Tank Structural Design

This involved the following considerations;

1. Modular ratio(m) of a composite material i.e., RCC, which is the ratio of modulus of elasticity of steel to the modulus of elasticity of concrete

$m = \frac{280}{3\sigma_{bc}}$, where σ_{bc} = permissible stress in concrete

2. Tensile forces, $T = \gamma H^2 D$

3. Quantity of reinforcements required,

$Ast = \frac{T}{\sigma_{st}}$, $T = \frac{\gamma H D}{2}$, where σ_{st} = permissible stresses in steel

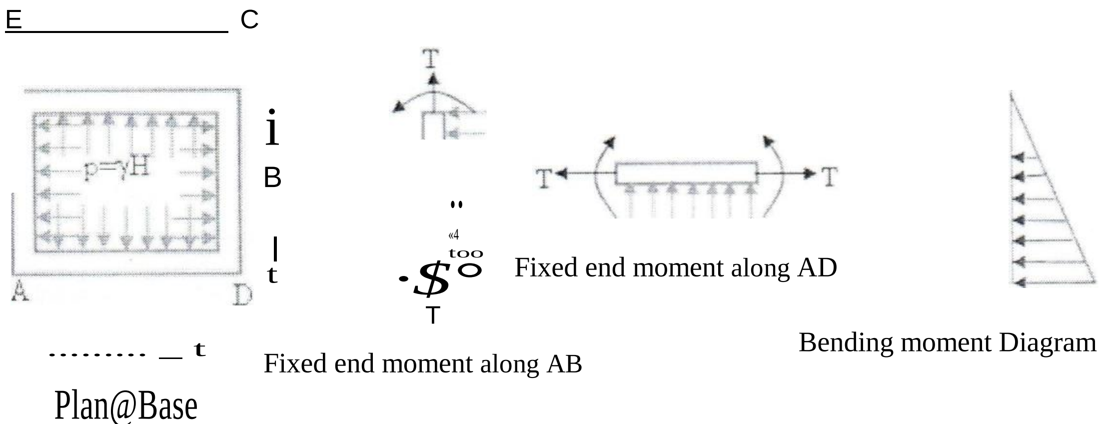


Figure 6: Water pressure exerted onto the storage tank walls, and the respective bending moment of the different sides of the storage tank

Figure 7: Shows the structural design plan, showing reinforcements needed in the storage tank walls.

Design specifications to meet the design needs: Concrete class M20 and steel grade Fe4 l 5 are to be used as per the design calculations of bending moments and tensile stress

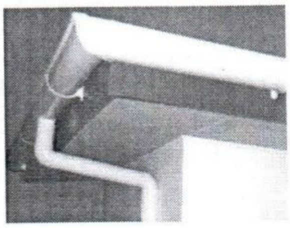
3 .2.5 Delivery System

This involved the use of gutters and downpipes to transport water collected from the catchment areas to the manholes and finally to the reservior (storage tank) using PVC pipes running through the ground.

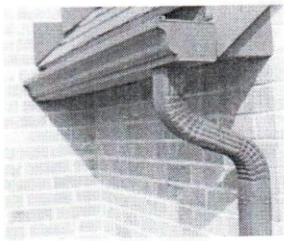
Gutters and downpipes

Gutters are used to capture the rainwater running off from the roof and downpipes are used to deliver the rainwater into the rainwater storage tank. Inadequate number of downpipes, excessive long roof length, steep roof slopes, and less perform gutter maintenance, are among the reasons of spillage or overrunning of rainwater. Therefore, it is advisable to consult the gutter supplier for the best installation.

In allocating potable use water system, gutter and downpipes cannot use lead material. This is due to slightly acidic quality of rain could dissolve lead and thus contaminate the water supply. The most common materials of gutters for both potable and non-potable systems are PVC, vinyl, seamless aluminum and galvanized steel **(Georgia, 2009)**



(a) Layout of half round gutters & downpipes



(b) Eaves Gutters

Figure 8: Roof Conveyance System

Gutters and downpipes design dimension allocations as per the existing catchment areas

Gutter and downpipes design involved the use of manning's formula and design tables to obtain the optimal components as per the catchment area.

Gutter capacity sizing

> $Q = \frac{1}{N} A R^{2/3} S^{\frac{1}{2}}$. Where

Q = Discharge (m?/sec), **A=** Cross-sectional Area of Flow (m^2), **R=** Hydraulic Radius (m), **N=** Coefficient of Roughness, **S=** Gutter Slope (m/m)

No.	BUILDING BLOCK	DISCHARGE, Q(m^3 /s)
1.0	Civil Laboratory	0.0158
2.0	Civil-Electrical Departments Office	0.0098
3.0	Library	0.0161
4.0	Dean's Office	0.0101
5.0	Computer Lab - Lecture rooms Block	0.0388
6.0	Staff Room	0.0137
7.0	Civil workshop	0.0360
8.0	Art - Department block	0.0421
9.0	Electrical-Mechanical workshop	0.073

Sizing of conveyance pipes (downpipes)

The size of the required pipe can be calculated using the following formula:

$a=Dv$.where

Q = Flow (m^3/s), **D** = Pipe size (m). **V** = Velocity (m/s) (obtained using newton's taking water to flow under the action of gravity only with an acceleration of 9 .81m2/sec)

v?=U+2as,

Where; V= Velocity of water entering the horizontal Discharge pipe =?U = Velocitywith which Rainwater enters the R.W.P. = 0.15m/sec. S= Height of the building

Table 6: Half round gutters and downpipes design table

Roof Area (m)	Roof Runoff Rate (LIS)	Half Round Gutters (diameter/mm)				Circular Downpipe (diameter/mm)			
		End outlet		Center Outlet		End outlet		Center Outlet	
		Cal. Size	Ava. Size	Cal. Size	Ava. Size	Cal. Size	Ava. Size	Cal. Size	Ava. Size
50	1.32	110	174	55.0	174	72.5	82	36.5	82
60	1.58	120	174	60.0	174	79.0	82	39.5	82
70	1.85	125	174	62.5	174	82.5	82	41.0	82
80	2.11	135	174	67.5	174	89.0	110	44.5	82
100	2.64	145	174	72.5	174	95.5	10	48.0	82
120	3.17	155	174	77.5	174	102.5	110	51.0	82
150	3.96	170	174	85.0	174	112.0	110	56.0	82
200	5.28	195	174	97.5	174	128.5	160	64.5	82

In reference to manual calculation done using the above design fomulars and the design table, the following were the respective downpipe and gutter sizes as per the catchment areas;

Table 7: Designed Downpipe and Gutter sizes as per the catchment areas

No.	BUILDING BLOCK	GUTTER SIZE (Inches)	DOWN PIPE SIZE (Inches)
1	Civil Laboratory	6"	4°
2	Civil -Elec Dept Office	6"	4"
3	Library	6°	4"
4	Dean's Office	6°	4°
5	Computer Lab Block	6"	4"
6	Staff Room	6"	4"
7	Civil Workshop	6°	4"
8	Art-Dept Block	6"	4°
9	Elec- Mech Workshop	6"	4"

3.2.6. Manhole Sizing

Considering calculations of volume per catchment area, flow velocities and pressures the underground delivery pipes were sized as 8inches and manholes are sized as 1000mm 1000mm

and 1500mm depth

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3 .2.7. Filtration Point Design

Filtration aims at removing suspended pollutants from rainwater collected over roof. It involves use of a filter unit, which is a chamber filled with filtering media such as fibre, coarse sand and gravel layers to remove debris and dirt from water before it enters the storage tank.

ln this project, the filtration point design involved use of the sand filtration method due to its effective removal of turbidity (suspended particles like silt and clay), color and microorganisms.

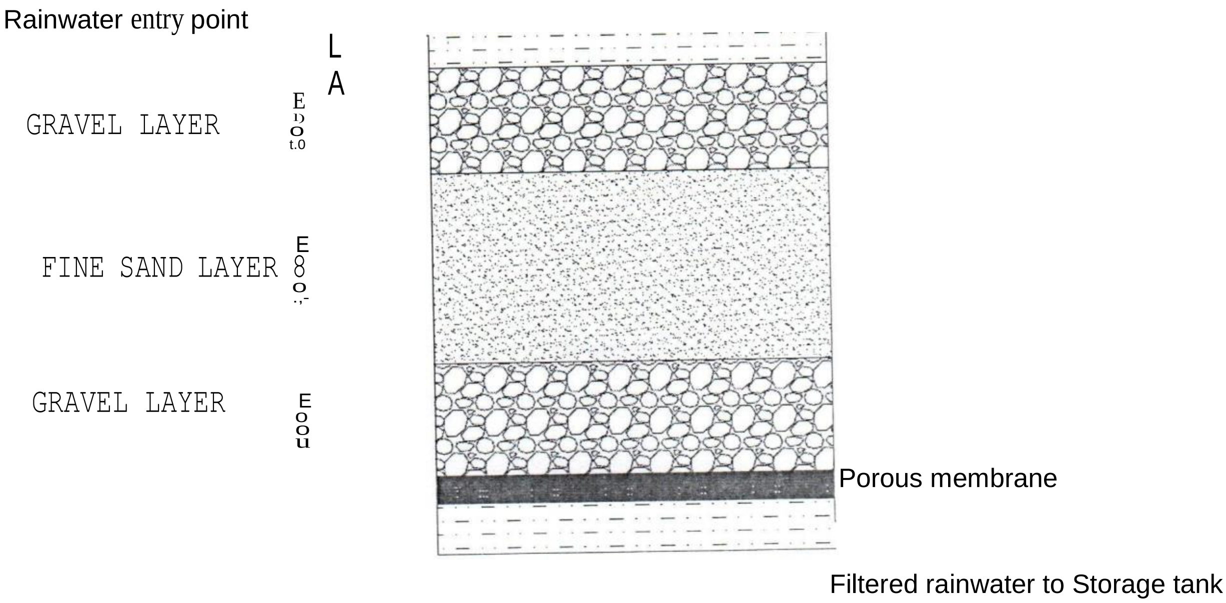

Figure 9: Designed Filtration Point System

CHAPTER FOUR: CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The rainwater harvesting is a simple and very useful technology during the rainy season. Water can be collected and used during times of scarcity. By doing this process we can save water for domestic purpose, drinking, gardening and future needs. lt is a very simple and affordable process and can be applied in any society without considering the rich or poor.

In summary, rain water harvesting is the best option.

RECOMMENDATIONS

Gutter installations must be done upon confirmation of the presence of facia boards since most of the structures observed had lost them over time. The supervisory engineer must ensure that down pipes running underground rest on structurally compacted material to his discretion.

The storage tank shall be constructed with concrete class M20 and reinforcement steel class Fe4 l 5 to the designed dimensions. Quick setting cement preferably should be used compared to the conventional cement due to the moist nature of site soils.

REFERENCES

Gould, J., 1992. *Rainwater Catchment Systems for Household Water Supply, Enviromental Sanitation Review*.

Ministry of water, March, 2009. Design manual for water supply and waste diposal. Juzuu ya 1.

Nissen-Peterson, G. &., 2015. *Rainwater harvesting systems.*

DIN 1989-1. 2002. Rainwater Harvesting Systems Part 1: Planning, Installation, Operation and Maintenance. German Institute for Standardisation, Berlin, 2002.

Runoff Rainwater Harvesting Practical action Technology Challenging poverty, Technical brief. http://www.practicalaction.org

Mrs. S.D. Khandagale#, Mrs. V .A. Joshi (Rainwater Harvesting: Grab hold of Water Where it Falls!)

APPENDIX

DESIGN LAYOUT PLAN

Ld4d.OJ1- *ILA)*