

**EVALUATION OF THE WATER SUPPLY AND SANITATION
SYSTEMS TO CHURCHES IN AKURE, NIGERIA**

BY

**OLUBAYODE, SMART ADELEYE
(CVE/95/6968)**



**THESIS WRITTEN IN THE DEPARTMENT OF CIVIL ENGINEERING AND
SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL
FULFILMENT OF THE AWARD OF MASTER OF ENGINEERING (M.ENG) IN
CIVIL ENGINEERING
(WATER RESOURCES AND ENVIRONMENTAL ENGINEERING OPTION)**

THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE

OCTOBER, 2010

DECLARATION

I, ENGR. OLUBAYODE, ADELEYE SMART declare that this thesis was prepared entirely by me under the supervision of Prof. A.M. Oguntuase of Department of Civil Engineering, Federal University of Technology, Akure.

The thesis has not been presented either wholly, or partly for any degree elsewhere before. All sources of information consulted have been duly acknowledged.

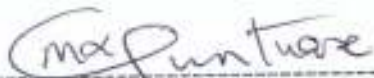

.....

OLUBAYODE, S.A.



CERTIFICATION

I certify that this project was carried out by OLUBAYODE, ADELEYE SMART of the Department of Civil Engineering, Federal University of Technology, Akure.



Prof. A.M Oguntuase
Supervisor

16 Nov 2010

Date

DEDICATION

This project work is solely dedicated to the Almighty God who gave me a sufficient grace to make this dream a reality.

May His name be exalted forever and ever.



ACKNOWLEDGEMENT

I thank God the Almighty God and give Him all the glory for the successful completion of this project.

I would like to wonderfully thank my supervisor, Prof. A.M. Oguntuase for his guidance, advice and valuable technical contributions from his wealth of experience. I am indeed grateful.

I also wish to express my appreciation to all those who have contributed in one way or the other to the success of this work. My special thanks go to, Dr. C. Arum, the Head of Department, Prof. S.A. Ola, the Chairman, School of Postgraduate Advisory Committee, Prof. J. O. Afolayan, the Dean of Engineering, Dr. J O. Babatola and Dr. A.O. Owolabi.

I am sincerely indebted to the brethren of Deeper Life Bible Church, Akure, I want to express my unalloyed gratitude to my wife, Mrs Olubayode Olayinka Abiodun whose stand words of encouragement from the beginning of the programme brought the much needed inspiration to continue the programme to completion.



TABLE OF CONTENTS

CONTENTS	PAGE
Declaration	ii
Certification	iii
Dedication	iv
Acknowledgement	v
Table of Contents	vi
List of Tables	xi
List of Figures	xiii
List of Plates	xv
Abstract	xvi

CHAPTER ONE

INTRODUCTION	1
1.1 General	1
1.2 Aim and Objectives	2
1.3 Scope of the Project	2
1.4 Justification for the Study	3

CHAPTER TWO

LITERATURE REVIEW	
2.1.0 Water Supply and Sanitation	4
2.1.1 Water Supply	5
2.1.2 Quantity of Water	5
2.1.3 Sources of Water Supply	5

2.1.4	Groundwater Pollution	6
2.1.5	Data on Wells and Boreholes Within the Study Area	7
2.1.6	Water Pollution	8
2.1.7	Main Types of Water Pollution	8
2.1.8	Causes of Water Pollution	9
2.1.9	Effects of Water Pollution	11
2.1.10	Control of Water Pollution	12
2.2.0	Demand	12
2.2.1	Water demand	13
2.2.2	Estimating per Capita Water Demand	18
2.2.3	Factors affecting water consumption	19
2.3.0	Types of demand	20
2.3.1	Excessive Pressure	21
2.3.2	Load Values (WSFUS) Assigned to Fixtures	22
2.3.3	Supply Piping	22
2.3.4	Selecting Pipe Sizes	23
2.3.5	Height of Installation	24
2.4.1	Water requirements (cold water requirement)	24
2.4.2	Water requirement and plumbing materials	26
2.5.0	General sanitation	27
2.5.1	Definitions	27
2.5.2	Aims and objects of sewage works	30
2.5.3	System of sanitation	30
2.5.4	Description of Human Wastes Disposal Systems	32
2.5.5	Conventional sewerage system	39
2.6.0	The Septic Tank	40
2.6.1	The Design of Septic Tank	43

2.6.2 The Disposal of Septic Tank Effluent	44
2.6.3 Design consideration	45
2.6.4 Disposal of Effluent from Septic Tank	46
2.6.5 Advantages and Disadvantages of Septic Tanks	48
2.7 Internal distribution system	49
2.8.0 Indicators for the Need for Sanitary Improvement	50
2.8.1 The Choice of Appropriate Sanitation Technology	50
2.8.2 Influence of Social Factors on Sanitation Alternatives	52
2.8.3 Influence of Cultural Factors on Sanitation Alternatives	53

CHAPTER THREE

METHODOLOGY

3.1 Study Area	55
3.2 Method of Approach	57
3.3 Physical Survey of Existing Water Supply and Sanitation Systems in the Study Area	58
3.4 Administration of Questionnaire for Attitude Survey	58
3.5 Analysis of the data collected	59
3.6 Design of Improved Facilities	59
3.7 Cost Estimates	59

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

4.1 Analysis of Data and Discussion of Result	64
4.2 Discussion of Physical Survey carried out	

in the Selected Churches

4.3	Water supply and Plumbing Installations	64
4.4	Data from Attitude Survey	65
4.5	Testing of Hypothesis	71
4.6	Design of water storage tank for three population levels:	78
4.6.1	Design of water storage tank for low population churches(up to 100 worshippers)	78
4.6.2	Design of water storage tank for medium population churches(between 100- 500 worshippers)	79
4.6.3	Design a water storage tank for large population churches(above 500 worshippers)	79
4.7	Design of a septic tank	80
4.7.1	Design a septic tank for low population churches(up to 100 worshippers)	80
4.7.2	Design of septic tank for medium population churches(between 100- 500 worshippers)	81
4.7.3	Design a septic tank for large population churches (above 500 worshippers)	83
4.8	Soak-away pit	84

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1	Conclusion	105
5.2	Recommendations	105
REFERENCES		107
APPENDICES		110

Appendix 1: Data on Sampled Churches	111
Appendix 2: Questionnaire	119
Appendix 3: Detail of Bill of Engineering Measurement and Evaluation for Detached Toilet Facility for 100 users	124

LIST OF TABLES

Table	
2.0 Data on Wells and Boreholes within the Study Area	7
2.1 Institution Water Demands	15
2.2: Industrial Water Demand	16
2.3: Branch Pipe Sizes	23
2.4 The Dimension of Septic Tank as per I.S. 2470 (part I)	41
2.5: The Dimension of Large Size Septic Tank as I.S. 2470 (Part II)	42
4.1: Supply of water in the selected churches	66
4.2: Type of toilet facility in use	67
4.3: Source of water supply	67
4.4: Distance of Toilets from the Church Auditorium	68
4.5: Table Preferred location of toilet facility	69
4.6: Anal cleaning materials	69
4.7: Type of maintenance in use	70
4.8: Population of Worshippers and Water Supply	70
4.9: Rate of disludging	71
4.10: Relationship between supply of water and source of water	72
4.11: Relationship between toilet facility and supply of water	73
4.12: Relationship between populations of worshippers against toilet facilities	74
4.13: Relationship between populations of worshippers against rate of disludge	75
4.14: Relationship between adequacy of toilet facilities and site ownership	76
4.15: Relationship between toilet facility and site ownership	77
Table 4.16 Summary of cost estimates for a typical,	

detached toilet building, toilet facilities and

water supply for 100 users

99

Table 4.17: Summary of cost estimates for a typical,

detached toilet building, toilet facilities and

water supply for 250 users

100

Table 4.18: Summary of cost estimates for a typical,

detached toilet building, toilet facilities and

water supply for 500 users

101

Table 4.19: Summary of cost estimates for a typical,

attached toilet building, toilet facilities and

water supply for 100 users

102

Table 4.20: Summary of cost estimates for a typical,

attached toilet building, toilet facilities and

water supply for 250 users

103

Table 4.21: Summary of cost estimates for a typical,

attached toilet building, toilet facilities and

water supply for 500 users

104

LIST OF FIGURES

Figure

3.1a: Map of Nigeria Showing Ondo State	56
3.1b: Map of Ondo State with the highlighted section showing Akure the study area	57
3.1c: Map of Akure town showing the Location of the Study Area	
3.2: The location of the selected study areas	61
4.1: Floor plan showing soil/waste water layout (Attached) for 100 users	86
4.2: Floor plan showing toilet and water supply layout (Attached) for 100 users	87
4.3: Floor plan showing front elevation and typical side elevation and facilities (Attached) for 100 users	88
4.4: Floor plan showing soil/waste water layout (Attached) for 250 users	89
4.5: Floor plan showing toilet and water supply layout (Attached) for 250 users	90
4.6: Drawing showing section Y-Y for toilet facilities (Attached) for 250 users	91
4.7: Drawing showing front elevation and typical side elevation and facilities (Attached) for 250 users	92
4.8: Floor plan showing soil/waste water layout (Attached) for 500 users	93
4.9: Floor plan showing toilet and water supply layout (Attached) for 500 users	94
4.10: Drawing showing section X-X for toilet facilities (Attached) for 500 users	95
4.11: Drawing showing front elevation and typical side elevation and facilities (Attached) for 500 users	96

4.12: Drawing showing the plan of septic tank, soak-away pit, section through water closet and schedule of septic tank size	97
4.13: Site Drainage	98



LIST OF PLATES

Plate 1- 6: Picture showing a typical toilet of churches
in Akure Metropolis

61-63



ABSTRACT

This project focuses on water supply and sanitation to churches in Akure local government area of Ondo State. To achieve this goal, randomly selected 150 churches within Akure were inspected to assess their conditions of suitability, adequacy and use by worshippers.

Questionnaires were administered to worshippers within the study area. In addition to the questionnaire, interviews questions were also conducted.

The data collected were tested and analyzed using chi – square hypothesis. The result of this analysis were used to provide a rational basis for designing workable prototype water supply and sanitation systems for the churches in the study area at three different population levels. The population levels include: designing a workable prototype water supply and sanitation facilities for low population churches (up to 100 worshippers), medium population churches (up to 250 worshippers), and large population churches (up to 500 worshippers). Cost estimates of the attached and detached toilet facilities provided in the design for three population levels were prepared.



CHAPTER ONE

INTRODUCTION



1.1 General

Safe drinking water and adequate sanitation are primarily the requirements for a good standard of living. It is an unfortunate fact that millions of people throughout the world lack the basic essentials of adequate water supply and sanitation. It has been estimated by the World Health Organization (WHO) that 80% of illnesses in developing countries are water/sanitation related. It is known that several people die each year from the combined effects of unsafe and inadequate water supply or sometimes poor sanitation. Our religious institutions (churches) are not left out of these inadequacies.

It is stated in many religion doctrines that cleanliness is half of faith and the key to prayer is cleanliness. Public institutions like churches are sacred places whose primary function is a place for divine worship.

Basically, religious institutions are looked upon for cleanliness in all its ramifications; such as moral, spiritual and social standards. Most often in these religious Institutions, it is preached that cleanliness is next to Godliness, yet the basis to achieve this divine prospectus is lacking. This is because the area of cleanliness has been neglected and is still suffering neglect. It is bad enough that there are no adequate facilities for water supply and waste water disposal in our religious centers, but it is worse to discover that some of the existing facilities are not functioning effectively or more importantly, they have outlived their usefulness.

The importance of adequate water supply and sanitation cannot be over emphasized. A major reason why these are required and are indispensable is the need to safeguard human health and provide a clean environment for the Faithful to achieve the required spiritual realm they seek with ease.

1.2 Aim and Objectives

The aim of this study is to determine and proffer suggestions as to how to provide water and adequate sanitation to churches in Akure metropolis.

The specific objectives of the research are to:

- a) assess the adequacy of the water supply and sanitation systems in selected churches in Akure, Ondo – State, Nigeria.
- b) determine the actual water supply requirements at peak periods in these churches.
- c) design a typical water supply and sanitation systems for the churches for 3 different population levels which can be adapted for implementation.

1.3 Scope of the Project

The enthusiasm for this research project was based on the opportunity of the worshippers in some churches in Akure metropolis, which led to the discovery that was a very unique problem of water supply and sanitation associated with these worship centers.

The research project covers about 60% of the churches in Akure metropolis which was divided into five geographical units. A total of one hundred and fifty (150) questionnaires were administered to thirty (30) churches sampled in each of the five units. The water supply and sanitation facilities in these churches were physically inspected to access their conditions. Personal observations were made on the attitude of the people towards water supply and sanitation.

The data collected were tested and analyzed using chi – square statistical tool. The result of this analysis was used to provide a rational

basis for designing a workable prototype water supply and sanitation for the churches in the study area at three (3) different population levels.

1.4 Justification for the study

The increase in population of worshippers to various religious centers and its anticipated overstretching of the minimal facilities calls for the necessity to have a prototype water supply and sanitation scheme for churches to cater for the cleanliness and convenience of the worshippers and its environment at all times.

It is anticipated that the study may reveal the level of provision of water supply and sanitation in the churches. From this, improved workable prototype designs can be produced for water supply and sanitation systems in public institutions, based on up – to – date data in accordance with existing engineering standards and codes of practice.

CHAPTER TWO

LITERATURE REVIEW

2.1 Water Supply and Sanitation

Water supply and sanitation are considered together as indivisible to human health. The **provision** of a potable water supply is a priority which cannot be denied. It was reported that the World Health Organization (WHO) has been on the drive to provide potable water supplies to communities in the developing countries (Witlod et al, 1982). Where implemented, it has significantly reduced the incidences of diseases

such as typhoid, dysentery and cholera. This success has to a degree obscured the fact that increasing the water supply also increases the problems associated with waste water. Installation of water supply without waste water disposal merely results in a shift from one dominant set of diseases to another. Such a shift develops only with time.

In a public institution such as a church, the limited financial resources, has always raised the question whether water supply with sanitation should be provided for a smaller number of people or water supply only should be provided for a larger number of people.

Public money is not always committed to religious institutions, but where it is allocated it should be adequate for water supply and sanitation. The criteria for selecting the particular system are efficiency at lowest cost and the expectation of continuous function, not the sophistication of the system.

In order to ascertain the type of improvement that is required for water supply and sanitation for worship centers it is most desirable to understand their technologies and evaluate the adequacies of their appurtenances.

2.1.1 Water Supply: Hydrological conditions like rainfall, runoff, and percolation must be understood in developing water supply. Rainfall infiltrates

into the soil, runs off over the surface, or is transpired by vegetation and also evaporates. There is condensation into cloud formation, and return to earth as rain or snow.

2.1.2 Quantity of Water: The quantity of water required for various purposes by a city, community or dwelling is a consideration for design.

The first step in the selection of a suitable water supply source is the water demand of the city, community or dwelling. It is also necessary to determine the total yearly demand as well as monthly demand variations (Challender and Hancock, 1974). The average daily demand is the average water consumption per capita per day supply at reasonable pressure, with reasonably efficient waste and leak prevention measures applied. The peak rate demand is the maximum water consumption per capita when many people are using water at the same time (Twort, et al, 1987).

2.1.3 Sources of Water Supply

The nature of the water source determines the planning, design, and operation of the collection, purification, transmission, and distribution works. Common sources of freshwater and their development are:

i. Rainwater.

Directly from the atmosphere harnessed by rainwater harvesting systems

ii. Surface water.

(a) From streams, natural ponds and lakes of sufficient size, by continuous drift.

(b) From streams with adequate flood flows, by intermittent, seasonal, or selective draft of clean flood waters and their storage in reservoirs adjacent to the streams or otherwise readily reached from them.

(c) From streams with low dry-weather flows out enough annual discharge, by storage of wet-weather flows in reservoirs impounded by dams thrown across stream valleys.

iii. Ground water.

(a) From natural springs ; From wells; from infiltration galleries, basins or cribs

(b) From wells, galleries and possibly springs with flows augmented from some other sources

(c) From wells or galleries with flows maintained by returning to the ground water previously withdrawn from the same aquifer for cooling or similar purposes.

2.1.4 Groundwater Pollution

An important consideration when employing on-plot sanitation systems is that of groundwater pollution. Due to the nature of on-site systems shallow groundwater can be exposed to the pathogens within faeces and become contaminated. In urban areas this can be particularly problematic especially if shallow groundwater is used for drinking. In general it is possible to reduce this risk by locating a latrine at least 10m horizontally from a groundwater source. There is often debate as to the costs associated with alternative sanitation systems as oppose to alternative water sources. An alternative means to reduce the risk of contamination to groundwater is to employ a raised pit latrine.



2.1.5 Data on Wells and Boreholes Within The Study Area.

For Akure, Data on the wells and boreholes obtained from WATSAN in 2009 is summarized in table 2.0 below:

Table 2.0: DATA ON WELLS AND BOREHOLES WITHIN THE STUDY AREA

Source: (WATSA, 2009)

S/NO	STUDY AREA	WELLS	BOREHOLES
1.	Alagbaka	Low water table, good yield depth of well; 60-70ft. Rate of recharge: more than 1ltr/sec.	High water table, high yield, weathered zone. Rate of recharge: more than 1ltr/sec.
2.	Ijoka	Good yield, high water table. Depth of well is between 45ft-70ft.	High weathered zone, high water table. Casing of the hole is required during drilling.
3.	Oda	Average yield, low water table, depth of well: 75ft.	Average yield, low water table. Recharge rate: less than 1ltr/sec
4.	Ijapo	Hard rock/sedimentary, okay for well good yield.	Hard rock/ sedimentary area, okay for borehole. Recharge rate: Less than 1ltr/sec.
5.	Central Market	Average yield, pollution is very high, well must not be less than 50ft. About 70ft deep is adequate.	Good yield. Recharge rate: Less than 1ltr/sec.
6.	FUTA	Good yield at depth of 30-35ft. Water table is high.	Low yield. Recharge rate: Less than 1ltr/sec. Water table is low.
7.	Ondo Road	Rocky area, low yield.	Low yield, okay for borehole. Recharge rate: Less than 0.7ltrs/sec.
8.	Oke-Aro	Good yield, water table is high. Recharge rate: More than 1 litre/sec	Good yield. Recharge rate: More than 1ltr/sec.
9.	Oshinle	Good yield. Recharge rate: 1ltr/sec.	Good yield. Recharge rate: 1ltr/sec.
10.	Oba-Ile Housing	Good yield. Recharge rate: more than 1ltr/sec. About 20% of the area is rocky with low yield. (close to the first and second gate)	Good yield. Recharge rate: more than 1ltr/sec. About 20% of the area is rocky with low yield. (close to the first and second gate)

Source: (WATSA, 2009)

2.1.6 Water Pollution

Water pollution almost always means that some damage has been done to an ocean, river, lake, or other water source. A 1971 United Nations report defined ocean pollution as:

"The introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hinderance to marine activities, including fishing, impairment of quality for use of sea water and reduction of amenities.

2.1.7 Main Types of Water Pollution

When we think of Earth's water resources, we think of huge oceans, lakes, and rivers. Water resources like these are called surface waters. The most obvious type of water pollution affects surface waters. For example, a spill from an oil tanker creates an oil slick that can affect a vast area of the ocean.

Not all of Earth's water sits on its surface, however. A great deal of water is held in underground rock structures known as aquifers, which we cannot see and seldom think about. Water stored underground in aquifers is known as groundwater. Aquifers feed our rivers and supply much of our drinking water. They too can become polluted, for example, when weed killers used in people's gardens drain into the ground. Groundwater pollution is much less obvious than surface-water pollution, but is no less of a problem. In 1996, a study in Iowa in the United States found that over half the state's groundwater wells were contaminated with weed killers.

Surface waters and groundwater are the two types of water resources that pollution affects. There are also two different ways in which pollution can

occur. If pollution comes from a single location, such as a discharge pipe attached to a factory, it is known as point-source pollution. Other examples of point source pollution include an oil spill from a tanker, a discharge from a smoke stack (factory chimney), or someone pouring oil from their car down a drain. A great deal of water pollution happens not from one single source but from many different scattered sources. This is called nonpoint-source pollution.

2.1.8 Causes of Water Pollution

Causes of Water pollution are: Sewage, Waste Water, Nutrients, Chemical Waste, Radioactive Waste and Oil Pollution.

Sewage

With over 8 billion people on the planet, disposing of sewage waste is a major problem. In developing countries, many people still lack clean water and basic sanitation (hygienic toilet facilities). Sewage disposal affects people's immediate environments and leads to water-related illnesses such as diarrhoea that kills 3-4 million children each year. (According to the World Health Organization, water-related diseases could kill 135 million people by 2020.) In developed countries, most people have flush toilets that take sewage waste quickly and hygienically away from their homes.

Yet the problem of sewage disposal does not end there. When you flush the toilet, the waste has to go somewhere and, even after it leaves the sewage treatment works, there is still waste to dispose of. Sometimes sewage waste is pumped untreated into the sea. Until the early 1990s, around 5 million tons of sewage was dumped by barge from New York City each year. The population of Britain produces around 300 million gallons of sewage every day, some of it still pumped untreated into the sea through long pipes. The New River that

crosses the border from Mexico into California carries with it 20-25 million gallons (76-95 million litres) of raw sewage each day.

In theory, sewage is a completely natural substance that should be broken down harmlessly in the environment: 90 percent of sewage is water. In practice, sewage contains all kinds of other chemicals, from the pharmaceutical drugs people take to the paper, plastic, and other wastes they flush down their toilets.

Waste water

A few statistics illustrate the scale of the problem that waste water (chemicals washed down drains and discharged from factories) can cause. Around half of all ocean pollution is caused by sewage and waste water. Each year, the world generates 400 billion tons of industrial waste, much of which is pumped untreated into rivers, oceans, and other waterways. In the United States alone, around 400,000 factories take clean water from rivers, and many pump polluted waters back in their place. However, there have been major improvements in waste water treatment recently. For example, in the United States over the last 30 years, the Environmental Protection Agency (EPA) has spent \$70 billion improving treatment plants that now serve about 85 percent of the US population.

Factories are point sources of water pollution, but quite a lot of water is polluted by ordinary people from nonpoint sources; this is how ordinary water becomes waste water.

2.1.9 Effects of Water Pollution

Some people believe pollution is an inescapable result of human activity: they argue that if we want to have factories, cities, ships, cars, oil, and coastal resorts, some degree of pollution is almost certain to result. In other words, pollution is a necessary evil that people must put up with if they want to make progress. Fortunately, not everyone agrees with this view. One reason people have woken up to the problem of pollution is that it brings costs of its own that undermine any economic benefits that come about by polluting.

Take oil spills, for example. They can happen if tankers are too poorly built to survive accidents at sea. But the economic benefit of compromising on tanker quality brings an economic cost when an oil spill occurs. The oil can wash up on nearby beaches, devastate the ecosystem, and severely affect tourism. The main problem is that the people who bear the cost of the spill (typically a small coastal community) are not the people who caused the problem in the first place (the people who operate the tanker). Yet, arguably, everyone who puts gasoline (petrol) into their car—or uses almost any kind of petroleum-fueled transport—contributes to the problem in some way. So oil spills are a problem for everyone, not just people who live by the coast and tanker operators.

Sewage is another good example of how pollution can affect us all. Sewage discharged into coastal waters can wash up on beaches and cause a health hazard. People who bathe or surf in the water can fall ill if they swallow polluted water—yet sewage can have other harmful effects too: it can poison shellfish (such as cockles and mussels) that grow near the shore. People who eat poisoned shellfish risk suffering from an acute—and sometimes fatal—illness called paralytic shellfish poisoning. Shellfish is no longer caught along

many shores because it is simply too polluted with sewage or toxic chemical wastes that have discharged from the land nearby.

Pollution matters because it harms the environment on which people depend. The environment is not something distant and separate from our lives. It's not a pretty shoreline hundreds of miles from our homes or a wilderness landscape that we see only on TV. The environment is everything that surrounds us that gives us life and health. Destroying the environment ultimately reduces the quality of our own lives—and that, most selfishly, is why pollution should matter to all of us.

2.1.10 Control of Water Pollution

There is no easy way to solve water pollution; if there were, it wouldn't be so much of a problem. Broadly speaking, there are three different things that can help to tackle the problem—education, laws, and economics

(source: [http://www.explainthatstuff.com/water pollution](http://www.explainthatstuff.com/water%20pollution))

2.2.0 Demand: Water demand is the rate of flow, usually expressed in liters per second furnished by a water supply system to various types of plumbing fixtures and water outlets under normal conditions (Harris and Cyril, 1990). The conditions in which any objectionable effects, such as excessive splashing or inadequate supply are avoided (Walker and Rodger, 1978) states that per capital per day water consumption figures can only be comparative from one area to another when it is determined if the flows are measured at the consumer's house meter, or as it enters the distribution system.

There is a considerable difference between the water consumption per capital for metered supplies as compared to unmetered supplies. Distribution system leakage is also a major factor, and a system with only a 10%

unaccountable loss is considered to be “bottle tight” many distribution systems have much more than 10% loss. Walker and Rodger, (1978) states that the Brussels water company in Belgium quoted 30% of average annual demand losses from water mains and service connections in the US are estimated to vary from 5% to 45% of the average flow. Unmetered services without exception result in water wastage. In many instances, the average demand of the city has been reduced by as much as 50% by installing meters on each services and charging customers for the water they use.

Once meters have been installed and the metered readings summed up to compare with the water leaving the treatment plant, then the unaccounted distribution system losses can be estimated and maintenance programmes can be instituted to locate and repair the broken mains and reduce the losses. However, this system is often practiced in Nigeria but is not effective. The cost advantages in metering each customer are accompanied by a reduction in water consumption, allowing the utility to serve more people than it could supply if water were sold on a flat rate. On the basis of water consumption per capital per day, the average domestic water requirement of a community and for house hold is calculated. In Nigeria, the average water consumption is estimated at approximately 160 liters per capital per day. (Walker and Rodger, 1978).

2.2.1 Water Demand

Before planning a water supply scheme, it is the engineer's duty to examine carefully the various types of water demand a city may have. The demand may be classified in the following categories:

- (1). Domestic water demand,
- (2). Institutional demand,
- (3). Industrial need,
- (4). Fire demand, and
- (5). Water unaccounted for.

It is important to assess each of the above demand to get an accurate and total picture of water requirements.

(1). **Domestic Water Need:** Under this head, the quantity of water required for various domestic usages, is ascertained. Domestic needs, such as bathing, drinking, cooking, flushing toilets, washing etc. come under this demand. The population of a city or town will be the most important factor, which will control the consumption of water under this need. A minimum rate of 70 to 100 liters per capita per day (lpcd) should be allowed for domestic need. The break up at domestic demand per day for a town per head basis may be assumed as given below:

(1) Water required for drinking	2 liters
(2) Cooking, washing etc.	10 to 12 liters
(3) For bathing, washing clothes	40 to 60 liters
(4) Flushing water closets	25 liters
(5) Other needs	<u>10 liters</u>
Total	<u>70 to 100 liters</u>

Depending on the relative importance, size, economic condition of a city, the rate of water demand will always be associated with non-domestic need also. As a general rule, the following allocation of water for domestic and non-domestic need, will give a guideline for initial assessment of water.

- i. For communities with population up to 10,000-----70-100 lpcd
- ii. For communities with population 10,000-50,000---100-125 lpcd
- iii. For communities with population above 50,000----125-200 lpcd

The requirement of each case will have to be studied with reference to the local factors governing the different needs before the optimum rate of supply for the community is decided upon. In case of rural communities where house service connections are not contemplated and the supply may be through hands pumps or central stand posts, the rate shall not be less than 40 lpcd. Where

house service connections are not contemplated, to make the scheme self-paying, the rate shall be at least 70 lpcd (Chatterjee, 2005).

- (2). **Institutional Demand:** This is also sometimes known as public demand and it includes the quantity of water required for various public utility purposes. The water required for various public buildings and institutions, public parks, playgrounds, gardening, sprinkling on roads, street foundations etc. will come under this demand. For many water supply schemes, the latter parts are believed to be not essential and only a nominal amount is kept for this. But the demand of water for various public institutions is well recognized and a specific allotment is made for each.

Table 2.1 Institution Water Demands.

Sl. No.	Types of Institution	Recommended rate (lpcd)
1	Hospital including laundry (a) Not exceeding 100 beds (b) Exceeding 100 beds	340 455
2	Hotels	180 (per bed)
3	Hostels	135
4	Restaurants	70 (per bed)
5	Air Ports and Sea Ports	70
6	Junction Stations	70
7	Terminal/Intermediate Stations	45
8	Day School/College	45
9	Offices	45
10	Factories	45
11	Cinemas/ Theatres	15

Source: Chatterjee, 2005.

(3) Industrial Demand: While the per capita rates of water supply will ordinarily include the requirement of small industries distributed within the town, specific provisions will have to be included in water supply, for meeting the probable demands likely to be made by specific industries. The water requirements for this purpose will depend upon the number, nature and size of industries. The rates of such water demand are given in table 2.2.

Table 2.2: Industrial Water Demand

S/No.	Nature of Industry	Units of Production	Water Requirements (Liters)
1	Automobile	Vehicle	40,000
2	Distillery	Liter of proof alcohol	122-170
3	Fertilizer	Tonne	80,000-2,00,000
4	Leather	Kg (tanned)	40
5	Paper	Kg	200-400
6	Special Variety Paper	Kg	400-1,000
7	Straw Board	Kg	75-100
8	Petroleum refinery	Tonne (crude)	1,500-2,000
9	Steel	Tonne	200,000-2,50,000
10	Sugar (cane crushed)	Tonne	1,000-2,000
11	Textile	Kg	80-140
12	Wood pulp (sulphate)	Tonne	2,40,000
13	Coke	Tonne	14,000
14	Ice	Tonne	1,850
15	Wool scouring	Kg	10-12
16	Thermal power	Mega Watt	1,50,000-1,60,000

Source: Chatterjee, 2005.

(4) **Fire Fighting Demand:** Fire demand is the quantity of water required for fighting a fire out-breaks. Water requirement is particularly essential for high value district. This quantity is normally obtained on the basis of certain empirical formulae. (Chatterjee, 2005)

The most used one in USA is given by National Board for Fire Underwriters as

$$Q = 1020\sqrt{P} (1-0.001\sqrt{P}) \dots\dots\dots(2.1)$$

where P = Population in thousands, and

Q = Rate of flow of water in US gallons per minute,

when converted into metric units, then expressed as,

$$Q = 64\sqrt{P} (1-0.001\sqrt{P})\dots\dots\dots(2.2)$$

where Q is in liters per sec

For Indian conditions, (Chatterjee, 2005), the above formula gives rather very high values. For Indian conditions, the storage of water for firefighting is recommended for towns having population over 50,000. A provision of fire demand may be adopted as $Q = 1,00,000 \sqrt{P}$, where Q is the liter of water required per day and P is the population in thousand. It is desirable that one third of fire-fighting requirements form a part of the service storage. The balance requirement may be distributed in several strategic points. The static tanks may be filled from the nearby ponds, streams, canals by water tankers wherever feasible to be drawn directly by fire fighting equipments. High rise building should be provided with adequate fire storage from projected water supply.

Multistoreyed buildings above 25m height have to be provided fire storage of its own, in addition to the domestic need. The storage capacity of 1,00,000 liters and can fight at a rate of 2250 lpm with a terminal pressure of 3 kg.cm² should be capable for fighting about 45 minutes. (Barry, 1998)

The fire fighting pumps may be located in the basement to have a positive suction head and designed to deliver at the rate of 2250 lpm with a terminal

pressure of 0.003 N/m^2 at the top most floor so as to obtain from the hydrant 900 lpm discharge with a jet of 6 m.

On the fire fighting pumps rising mains, hydrant tees of 60 mm may be provided at every landing of stair case. A small 20 mm tapping may be provided at each landing with a wheel valve and adequate length of house pipe for fighting small fire.

- (5) Water unaccounted for: This includes the quantity of water due to wastages, losses, theft etc. Some water is lost due to leakages at joints and valves. Some loss may take place due to illegal and unauthorized connection. These losses can be reduced by providing good quality joints and fittings and also by guarding against water thefts. Timely maintenance and proper inspection and investigation will vastly reduce the water losses. For a well managed water work, this quantity should not exceed 20 per cent of total water supply.

2.2.2 Estimating Per Capita Water Demand

This is required for finding out the total water requirement of a town. It is done by finding out water need for each head as discussed above. Addition of all these will give the gross water requirements which may be summed up, and the figure may be divided by the population of the concerned area, to give equivalent per capita water demand. Thus, both the domestic and non-domestic needs are expressed with relation to population. The following example rates of a town under various heads may be assumed, (Chatterjee, 2005) as:

i. Domestic need	100 lpcd
ii. Institutional/Public requirement	20 lpcd
iii. Industrial demand	30 lpcd
iv. Fire demand	15 lpcd
v. Water unaccounted for	<u>35 lpcd</u>

From the above, it can be seen that gross water requirement will be 200 liters per capita per day. If the total population of the town is ascertained, the water demand per day may be assessed.

2.2.3 Factors Affecting Water Consumption

There are certain factors which control the water consumption rate. For making a correct assessment of water requirement, they should be borne in mind.

The factors can be summarized as given below: (Chatterjee, 2005)

- (i). Climatic Condition: Climatic condition has great influence on water consumption rate. The water consumption rate in hot and arid regions will tend to increase as compare to wet and cold places.
- (ii). Standard of living: For cities with high standard of living, the water consumption will be higher. For poor people, the per capita demand of water is low.
- (iii). Industries: Water requirement not only directly depends on nature, number and size of industries, but also their indirect relation to over all development. For industries areas water demand also should be properly linked with fire demand. In general, with the increase of industries water demand will rise.
- (iv). Quality of water: If the quality of water is good, the people will consume more water. Otherwise, they may avoid and try to use minimum quantity of water. So for safe and good quality water, water consumption will be higher.
- (v). Pressure in the distributed system: If the pressure in the distributed system is high, that will cause not only high rate of flow, but also leakages will be high, thus, increases per capita demand.

- (vi). System of sanitation: If the towns are provided with water carriage system of sanitation, per capita water demand increases.
- (vii). Use of meters: If the metering is introduced for the purpose of charging for consumed water, the consumer will be cautious in using water and there will be less wastages of water. So per capita demand may lower down. But, it is not necessarily; this saving of water will make the water works run economically. For metering, there would be not only cost of initial capita investment, but also regular establishment and maintenance cost. Secondly, too less use of water by consumers may lead to unhygienic conditions.

2.3.0 Types of Demand

(Twort et al, 1985) states that it is convenient to divide water consumption into the following categories:

- (a) domestic: - In- house- drinking, cooking, ablution, sanitation. House cleaning, car washing, clothes washing, sprinkling, garden watering, lawn sprinkling, stand pipe from public stand pipes and fountains.
- (b) trade industrials: - Factories, industries, power-stations, dock commercial-shops-offices, restaurants, and small trade etc, Institutional-schools, hospitals, universities, government offices, churches, mosques and so on.
- (c) losses:- Consumer wastage-leakage and wastage from consumer premises, misuse or unnecessary wasteful use of water by consumers: distribution loses leakages and overflow from service reservoirs, leakages from mains, service pipes and service pipe connections, leakages from valves-metering and other losses source meter error, supply meter errors, unrecorded consumption.

Domestic in- house demand as stated by (Twort et al, 1987) varies widely from one house to another, even in identical housing. The “in-house” demand is that used for domestic purposes, excluding garden watering and lawn sprinkling but including washing cars and cleaning down outside yards. It is quite common to find house holds in which the per capital consumptions is two or three times the average (Twort et al, 1985).

(Birdie et al, 1992) classified types of demand similarly and states that it is not possible to accurately determine the actual demand in addition to the fact that certain empirical formulae and thumb rules are employed in determining the water demand, which is near to the actual demand.

According to the author the following are the various types of water demands of a city or town:

- (a) In India on the average, the domestic consumption of water under normal conditions is about 135Liters/day/capita.
- (b) In Nigeria, it is between 135 – 165Liters/day/capita.

The details of the domestic consumption are given below:

2.3.1 Excessive Pressure

To avoid excessive flow rates and splashing at fixture where the available pressure is considerably higher than the minimal required, it is generally necessary to provide some means of reducing the maximum flow rate to match the normal valves (Harris and Cyril, 1990). This is especially required at fixtures on the lower floors of high and tower type buildings, for at such locations the pressure in the individual fixture supply pipe is several times greater than the minimum required at water outlets.

Where the available pressure at water outlets is more than twice the minimum pressure required for satisfactory supply, it is recommended that the device to control the flow rate be provided in the fixture supply pipe. For this

purpose, individual regulating valves, variable-orifice control devices, or fixed orifices may be provided. For faucets and flush tank tall cocks. (Harris and Cyril, 1990) states that a throttling valve or flow-control orifice may be installed in the fixture supply pipe to reduce the maximum flow rate to match normal demand. To control faucet flow, throttling valves should be adjusted so that flow matches demand when the faucet is wide open-flow-control orifice should be selected in accordance with the desired demand and anticipated supply pressure.

2.3.2 Load Values (WSFUS) Assigned to Fixtures

The demand imposed on a system by intermittently used fixtures is related to the number, type and probable simultaneous use of the fixtures to be supplied (Harris and Cyril, 1990). In the standard method, fixtures using water intermittently under general conditions of service are assigned specific load values in terms of water supply fixture units. The water supply fixture unit (WSFUS) is a factor so chosen that the load producing effects of different kinds of fixtures and their condition of service can be expressed as multiples of that factor. For fixtures having both hot and cold water supplies, the values for separate hot and cold water demands should be taken as being three fourths ($3/4$) of the total value assigned to the fixture in each case. For example, the value assigned to a kitchen sink in a dwelling unit is 2 WSFU, while the separate demands on the hot and cold piping there should be taken as being 1.5 WSFU.

2.3.3 Supply Piping

Materials, fittings and values must be selected for trouble free service during the expected life of the piping system (Blankenbaker, 1987). PVC, copper or galvanized iron pipe and fittings are suitable for installation of the water

supply system, in general, black iron and lead pipe should not be used in the water supply system, because of the toxicity of the material.

2.3.4 Selecting Pipe Sizes

Selecting pipe to provide adequate water supply is a matter of determining or predicting demand at each fixture and matching the probable demand with the ability of piping to deliver the proper flow (Blankenbaker, 1987). Others have already predicted the probable need at each fixture and recommended a suitable size of pipe. These are summarized in table 2.3. Following the recommendations in Table 2.3, the branches to the lavatory and the tube should be 12 mm diameter. The water closet needs only a 9 mm line. In practice, though the water closet branch would be 12mm pipe. Only the finished, exposed pipe would be 9 mm.

Table 2.3: Branch Pipe Sizes.

FIXTURES	PIPE SIZE(mm)	FIXTURES	PIPE SIZE(mm)
Bath Tub	12	Shower	12
Dishwasher	12	Urinal-Flush Value	9
Drinking fountain	9	-Flush Tank	12
Hose Bib	12	Washing Machine	12
Kitchen sink	12	Water-Closet-Flush Value	25
Laundry dry	12	Flush Tank	9
Lavatory	12	Water Heater	12

Sources: (Blankenbaker, 1987).

There is a rule of thumb for sizes of pipes which supply two or more branch lines, according to the author.

- (i). Up to three 9mm branches can be supplied by 12 mm pipe.

- (ii). Up to three 12mm branches can be supplied by 18 mm pipe.
- (iii). Up to three 18mm branches can be supplied by 25 mm pipe.

In the residential and small commercial installations on adequate water supply can be generally be obtained by following the procedures which need attention when selecting pipe sizes.

- (i). Height of the installation above the entry of the water supply into the building.
- (ii). Length of pipe.
- (iii). Number and type of fittings installed.

2.3.5 Height of Installation

Pressure to force water through the water supply piping is produced in two different ways (Blankenbaker, 1987):

- (i). By pumping water into a water tower and permitting it to feed the water mains using the force of gravity. This system is typical of publicly owned water supply system.
- (ii). Using a pump to push the water through the water supply piping system. This method is frequently used in privately owned residential water system.

2.4.1 Water Requirements

All buildings must be provided with portable water in quantities adequate for the needs of their occupants. Plumbing fixtures devices and appurtenances should be supplied with water in sufficient volume and at pressures adequate to enable them to function properly (Harris and Cyril, 1990). The pipes conveying

the water should be of sufficient size to provide the required water without due pressure reduction and without noise under all normal conditions of use. Plumbing should be design and adjusted to use the minimum quantity of water consistent with proper performance and cleansing of fixture and appurtenances.

Demand in building water supply cannot be determined exactly, most plumbing fixtures in buildings are used intermittently, and the probability of simultaneous use of such fixtures cannot be definitely established (Harris and Cyril, 1990). In addition, each type of plumbing fixture imposes its own singular loading effect on the system. This may be attributed to:

- (b) Average rate of supply required by a fixture for satisfactory service
- (b) Duration of use, and
- (b) Frequency of fixture use.

Nevertheless, the demand imposed on the building water supply system by intermittently used fixtures is related to the number, type and probable simultaneous use of the fixtures to be supplied. For a method to be generally acceptable for estimating the demand of a building water supply system it must meet three basic requirements (Harris and Cyril, 1990):

1. It must produce an estimate greater than the average demand for all fixtures on the system during periods of heaviest demand, otherwise, failure will occur in the supply to some fixtures during maximum demand period.
2. The method must yield reasonable accurate estimate of peak demand so as to avoid over sizing of piping and uneconomical waste.
3. The method must be adequate for estimating the demand of groups of like fixture as well as of different kinds of fixtures and building occupancy classifications.

2.4.2 Water Requirement and Plumbing Materials

(a) **Water Requirements in Residential buildings:** In residential building water is used extensively for cooking, washing, flushing, bathing, cleaning and drinking. All these essential activities are carried out daily, for health and cultural reasons. In order to meet all the water requirements at low cost, residential buildings are normally designed to obtain their water supply from water authority main. The mains as a portable water supply source offers a lot of advantages to the property owner such as ease of connection, less space required, low cost maintenance and less time consuming during installations. It is the cheapest form of water source in the long-run.

In some residential buildings, provisions are made for the period of mains failure by use of elevated storage tank, while in some, storage tank is completely dispersed with.

In the later case the intermittent loss of water supply during mains failure tends to defeat the purpose of installing an efficient plumbing system in the building.

(b) **Water Requirements in Institutional Buildings:** In an institutional building, the use to which they put water is similar to that of residential building because of:

- (1) The population
- (2) The nature of the building, and
- (3) The nature and character of the people living in the building.

Consequently, it is preferred to have an underground reservoir to subsidize the water mains in some institutional building while some solely depend on the underground reservoir. A pump is used to lift water into the elevated storage tank on top of the building to serve the fixtures in the building directly. While the system may be expensive it is the best, to avoid any undesirable and inescapable shortage of water.

(c) **Water Requirements in Factory Buildings:** Many factory buildings, especially those in which the production solely depend on water, make use of bore holes as their main source of supply. This is to avoid the possible risk of mains failure that may arise at any unexpected time.

Some factories that need water only for flushing, drinking and washing still choose mains water supply as their water source and sometimes, they may not even care to provide elevated storage tank, even though it is advisable to do so in order to enjoy optimum water supply services at all time.

2.5.0 General Sanitation

With the growth of the cities, the more primitive methods of excreta disposal have necessarily given place to the water carriage system. Even in the small towns the greater safety of sewerage, its convenience, and freedom from nuisance have caused it to be adopted wherever finances permit.

It is the duty of a sanitary engineer to judge the feasibility of any new sewerage scheme for a town, its construction and maintenance during operation. He should be responsible for safe disposal of waste materials of a community and keep a good sanitary condition of a town. He should also be responsible for protecting ground against sewage pollution. Sanitary engineers through proper control and management of sewage disposal, refuse sanitation, air pollution control etc. keep a clean and healthy environment and prevent the transmission of diseases.

2.5.1 Definitions

Sewage: It is the liquid waste from a community and is generally conveyed by a sewer. Sewage is classified in different forms depending on it

nature and sources. Domestic sewage is that which originates in the sanitary conveniences of a dwelling, business house or institutions. Industrial waste is the liquid waste produced from industrial processes, as drying, brewing, paper making etc. According to some authors (Harris and Cyril, 1990), (Chatterjee, 2005), concluded that domestic sewage together with industrial waste is termed as sanitary sewage. Storm water is the liquid flowing in the sewer during or following a period of rainfall and resulting therefrom. Some underground water may find its way through joints into sewerage system this is termed as infiltration. Of all these types of sewage, sanitary sewage which contains waste organic matters and other pollutants are harmful in nature. Storm water may be as high as twenty times that of sanitary sewage in quantity, but qualitatively it is much harmless in nature and less polluted. (Chatterjee, 2005)

Sullage: There is a distinct difference between sewage and sullage which is the spent up water from kitchen, wash basins etc. It does not include waste from urinals, water closets, stables etc; it is normally carried with the domestic sewage where a sewerage system exists. But as the sullage water is less foul in nature than sewage, in unsewered areas, it may be carried through surface drains for disposal whereas excreta disposal may be done by means of septic tanks etc.

Sewer: A sewer is a pipe or conduit generally closed but normally not flowing full, used for carrying sewage. A sanitary sewer is one which carries sanitary sewage and excludes as far as possible storm sewage. A storm sewer is designed to carry all types of sewage, such as domestic sewage, industrial wastes, and storm water.

Drain. It includes surface drains of different shapes and sections. There are used for carrying storm of water, sullage etc. surface drain may be uncovered or covered with suitable slab.

French drain: A French drain is also a surface drain filled up with crushed stones or gravels of desired sizes. This permits the flow through the

voids in any depression of ground surface. Due to ground surface washings the pore spaces get filled up with silt etc. and needs washing of packing materials and refilling after certain intervals.

Sewerage system: This is the system of sewers including all appurtenances required for sewage disposal. A sewerage system will consist of mainly:

- (i) Collection work,
- (ii) Treatment works if any, and
- (iii) Disposal works

Collection works are provided for collecting sewage from different points of occurrences and conveying sewage to any desired points with the help of a sewer system. Different types of sewers needed are house connections i.e. sewer from individual houses to public sewers, laterals, branches, sub-mains, mains, trunk and outfall sewers. Laterals will be single sewer and it will not receive sewage from a branch sewer excepting house connections. Two or more laterals meeting together will form a branch sewer. Similarly two or more branches will form a submain. More than one submain meeting together will form the main sewer. When more than one mains meet and form ultimately a single sewer directed to the treatment unit is known as trunk sewer.

Sewage treatment covers any artificial process to which the sewage is subjected in order to remove or alter its objectionable constituents so as to render it less dangerous or offensive.

Sewage disposal applies to the act of disposing of sewage by any method may be to a body of water or on land. It may be done with or without any previous treatment of the sewage. The last stretch of trunk sewer carrying sewage to the disposal point is known as outfall sewer.

Invert: This is the lowest point of the inside surface of the sewer or drain at any cross section (Chatterjee, 2005).

2.5.2 Aims and Objectives of Sewage Works

Sewage system in a city is provided for disposing spent up water. In doing so the human waste is also carried to the sewers. Sewers are provided also to prevent flooding of the city following a rainfall. The aims and objects of sewerage works may be summarized as indicated below:

- (a) To provide a good sanitary environment condition in a city.
- (b) To dispose the human excreta to a safe place by a safe and protective means
- (c) To dispose of all liquid wastes from a community to a proper place for preventing a favorable condition of mosquito breeding, fly developing or bacteria growing
- (d) To treat the sewage if required so as not to endanger the body of water, or land to get polluted where it is finally disposed of.
- (e) Proper disposal method should be adopted to protect sub soil water getting polluted. (Chatterjee, 2005)

2.5.3 System of Sanitation

A system of sanitation is classified on the basis of methods of collection and conveyance of waste produced in a community. This is mainly related to excreta disposal. The methods of collection adopted are mainly following two types:

(a) Dry or conservancy system, and (b) Water carriage system

(a) Dry conservancy system: This system of sanitation is in practice since ancient time. It is adopted where no sewerage system exists. Conservancy system is also known as scavenger system. In this system all sorts of refuse from a community is collected first in dust bins or garbage vats, which area located at suitable points inside the town ship. From this dust bins the refuse is collected

and carried by trucks or carts to the point of disposal. Disposal of refuse is done by means of land filling, incineration, composing or by dumping in the sea.

Human excreta or night soil is collected separately in privies or conservancy latrines. From where sometimes excreta along with liquid waste from latrines are collected to cesspool. Human agency is employed in removal of these wastes. These wastes are ultimately disposed of by trenching or otherwise. Covered trucks or tankers are employed in conveying this to the disposal point.

Storm water and sullage are collected and conveyed through surface drains to the disposal points. Disposal of this is done without any treatment to the natural water courses or otherwise. Dry or conservancy system for excreta disposal has been banned through legislation and should not be practiced any more. At the most its study may have some historical importance. (Chatterjee, 2005)

(b) **Water Carriage System:** Water carriage system of sanitation is a modern one. Here, no human agency is directly employed for collection and conveyance of night soil. Spent up water for domestic use which otherwise goes to waste is employed carrying night soil, hence the name is given as water carriage system. Some additional water is required for flushing and collecting large excreta. In this system of sanitation the volume of water requirement is comparatively large and the sewage thus produced is carried through properly designed sewerage system. The disposal of sewage is done to a body of natural water or on land generally after doing required treatment. Refuse disposal is done in the same way as in case of dry system. Storm water may be carried along with the same sets of sewers in combined sewers or may be disposed of separately in separate sewerage system.

2.5.4 On-site Sanitation Systems

Simple Pit Latrine

On-site sanitation systems are more widely employed in low income and rural areas of the world. Numerous forms have been developed ranging in both price and complexity. A number of publications exist that outline the features of different types and the consequences of employing them. This brief simply outlines the range of technologies in common use and the main advantages and disadvantages.

Depending on the types of latrine adopted the cost to the householder may be (relatively) much less than with off-site systems and would generally be covered in one lump sum for the construction of the facility (although the cost of emptying can be large in some cases). Each latrine type will provide both advantages and disadvantages, and are generally more appropriate for rural areas. Odour, flies and the need for emptying are the most important considerations associated with on-site systems.

A simple pit latrine is perhaps the simplest and the first step among sanitation solution identified by the UN to meet the criteria of the Millennium Development Goals (JMP, 2004). In reality the variance in the standard of these facilities can be great. The JMP distinction is that the latrine should have a superstructure to be acceptable to users.

The simplest form of pit latrine is a hand dug pit that is unlined and covered with a series of wooden logs strapped together allowing the user to defecate into the pit.

Advantages	Disadvantages
Construction costs are low (householders can perform a large part of the work themselves)	Possible groundwater contamination if the pit is not completely lined
Technology is simple and understandable	Not easy to construct in rocky or unstable ground
Allow range of anal cleansing materials	Fly and smell nuisance
Do not require water to operate	

Raised Latrines – When the groundwater is high or the ground is too rocky to excavate by hand there is a case for using a raised pit latrine (other latrine types can also be raised although it is more common for simple pit latrines to be raised). One major disadvantage is the lack of privacy afforded to the users of the latrines.

Slab type – There are numerous types of slabs that can be used for a latrine, each with different benefits. The purpose of the slab is to hold the weight of the user over the pit, provide a clean surface for the users feet and drain liquids into the squat hole. A variety of materials can be used such as timber, reinforced concrete and un-reinforced concrete slabs in a dome shape to avoid tensile forces. San-plats are often added onto traditional latrine slabs to provide a clean surface, foot plates and a suitably shaped squat hole.

Stoppers – Flies and smells can be the biggest problems associated with simple pits which can be controlled to some extent with a drop-hole cover or stopper.

Ventilated Improved Pit (VIP) Latrine

During the 1980s the VIP latrine was developed in Zimbabwe. The main drivers for design were to eliminate two unpleasant aspects of using on-site sanitation systems, flies and smell. Furthermore, the reduction of flies can also reduce the transmission of disease.

Put simply, the technology facilitates the flow of air through the system. One important aspect is that the inside of the toilet should remain dark as means of attracting flies up a vent pipe where they will eventually die and fall back into the latrine. Further information and details on construction can be found in the Practical Action technical brief 'Ventilated Improved Pit Latrine'.

Advantages	Disadvantages
Construction costs are low (householders can perform a large part of the work themselves)	Possible groundwater contamination if the pit is not completely lined
Technology is simple and understandable	Not easy to construct in rocky or unstable ground
Allow the use of a range of anal cleansing materials	Does not control mosquitoes
Do not require water to operate	Vent pipe increases costs and can make construction more complicated
Controls smells and flies	Need to keep inside of latrine dark
	Increased odour outside

Pour-flush Latrine

Where water is more widely available or traditionally used for anal cleansing a

Ventilated Improved Pit (VIP) Latrine

During the 1980s the VIP latrine was developed in Zimbabwe. The main drivers for design were to eliminate two unpleasant aspects of using on-site sanitation systems, flies and smell. Furthermore, the reduction of flies can also reduce the transmission of disease.

Put simply, the technology facilitates the flow of air through the system. One important aspect is that the inside of the toilet should remain dark as means of attracting flies up a vent pipe where they will eventually die and fall back into the latrine. Further information and details on construction can be found in the Practical Action technical brief 'Ventilated Improved Pit Latrine'.

Advantages	Disadvantages
Construction costs are low (householders can perform a large part of the work themselves)	Possible groundwater contamination if the pit is not completely lined
Technology is simple and understandable	Not easy to construct in rocky or unstable ground
Allow the use of a range of anal cleansing materials	Does not control mosquitoes
Do not require water to operate	Vent pipe increases costs and can make construction more complicated
Controls smells and flies	Need to keep inside of latrine dark
	Increased odour outside

Pour-flush Latrine

Where water is more widely available or traditionally used for anal cleansing a

pour flush latrine may be appropriate and can bring a number of further benefits on top of simple or VIP latrines. A water-seal is created by a plastic u-bend which prevents bad odour and flies affecting the user (this system is less susceptible to building errors than the VIP system). The system only requires a few litres of water and so should not put a strain on resources and could be provided by greywater from the kitchen.

Advantages	Disadvantages
The system effectively reduces levels of flies, mosquitoes and odour	Requires a supply of water to operate the system
The system can incorporate an offset pit (see below) and so can be installed inside a household	The water seal prevents the use of solid anal cleansing materials
The installations are easy to keep clean	The plastic pan requires increased skill to produce
They work easily i.e. the construction is not as complicated as a VIP latrine	More expensive than simpler types

Offset pits : These are a means of improving the operational nature of a latrine, but may increase the cost of construction and increase the complexity of the system. Two main advantages of employing an offset pit are to make emptying easier without having to disturb the superstructure and they can also enable the toilet to be constructed inside the house.

Single or Double Pit : It is also possible to include a double pit, this involves the need to change the direction of flow between pits. The advantage of a double pit is that the contents of one pit gradually decompose over time whilst

the other pit used and become safer to remove. The sanitation facility also becomes a more permanent piece of infrastructure as the superstructure never has to be removed. One area for caution is to ensure that the double pits are operated correctly.

Ecological Sanitation Latrines

Ecological sanitation (ecosan) latrines have been developed employing the concept that human waste contains nutrients that should be returned to the soil and used to grow more food. There are different types of toilet, which treat the waste to some extent prior to using the by-product to increase fertility of land. The types of toilet can be split into dehydrating and composting types with urine diversion often being employed to make the most of the nutrients available.

More information can be found in the Practical Action technical notes 'Ecological Sanitation: A Concept' and 'Re-use of Faeces and Urine from Ecological Sanitation'.

Advantages	Disadvantages
Recognises urine and faeces as useful by-products which can provide users with a cheap fertiliser and soil conditioner	Require appropriate training of users to ensure the systems are operated correctly and people not put at risk
Reduces pollution problems associated with some forms of wastewater disposal	Typically systems do not accept a wide variety of anal cleansing materials
	More expensive than simpler types of latrine

Aqua-Privy

An aqua-privy functions in a similar manner to a septic tank whilst avoiding the need for a consistent water supply to operate a flush toilet. The water will drain off the top and the sludge needs to be emptied on a regular basis. An advantage of the aqua privy is that it reduces odours. However, regular emptying could become an onerous requirement.

Advantages	Disadvantages
Does not require a piped water supply as a user can defecate directly into the tank	The system can fail to reduce smells if the water seal is not maintained
It is a cheaper form of a septic tank	Water must be available and plentiful
	Requires emptying
	Permeable land is needed to drain effluent

Septic Tanks

A septic tank is a water tight tank that typically receives waste from a flush toilet. They are useful in areas with a high water table (due to the sealed nature contamination of the water table is less likely) and when a reliable water supply is present. The system provides some level of treatment to the waste through the separation of solids.

The tank should be emptied routinely to ensure effluent does not contain unsafe levels of pathogens and that the sludge does not occupy too high a proportion of the tank. Ideally the effluent from the septic tank should be attached to a sewerage system, however in many cases the outlet is connected to a drainage field (if this is the case the ground should be permeable enough to prevent

ponding). This liquid effluent will not be completely clear of contaminants hence the requirement to avoid ponding.

Advantages	Disadvantages
The system reduces the level of odour and flies	The system comes at a high cost – including the cost of land
The user has the convenience of a WC which can be located indoors	Water is required (both in quantity and reliability)
	Permeable soil is required for drainage
	Requires regular emptying

Other Forms of On-Site Sanitation

There are other forms of sanitation which are less used or unsanitary. Borehole latrines are often used in emergency situations but adopted less elsewhere.

Unsanitary forms would include overhung latrines which will dispose directly into a watercourse or bucket latrines where users defecate into a bucket which is routinely emptied.

Emptying Latrines

Decomposition of waste takes place to some extent but eventually the superstructure will have to be located and a new pit excavated, or the pit will need to be emptied. The biggest problems become apparent in urban locations where there is little space to relocate or access a latrine and where increased population density increases loading on latrines and thus increases filling rates. The waste must also be safely disposed of, or else the very pollution sanitation was designed to avoid will still take place.

The options available for emptying and notes about filling rates and other important considerations can be found in the Practical Action technical brief 'Pit Emptying Systems'.

Upgrading sanitation type

One useful consideration to note is that on-site sanitation systems are not necessarily confined to one type. If designed with forethought then a toilet can be upgraded gradually as a means to progressively improve the service or adapt it to changing conditions.

2.5.5 Conventional sewerage system

This is a system where excreta is mixed with large volume of water from a cistern-flush and is removed from house in a flow along pipes or sewers to a treatment plant. The first "modern" sewerage system was built in Hambury, German, in 1842, by an innovative English engineer named Lindley (Howard et al, 1985). There can be no doubt that if funds are unlimited, conventional sewerage satisfies all the criteria for satisfactory excreta disposal, (Pickford, 1981). The major advantages of conventional sewerage, in addition to safeguarding public health, are a high degree of user convenience (Edwards, 1992). There are, however, technical and financial constraints which often make sewerage systems less suitable option, in many situations, for developing countries (Mara, 1976).

From the finding of many investigators, the difference between the various types of system, so far as public health is concerned, is not much, as long as they are correctly built, maintained and used (Cairncross and Feachem, 1983; Dangerfield, 1983). However, septic tanks have limited use in municipal areas. Their effluents are odorous, high in chemical oxygen demand, and dangerous because of possible content of pathogenic organisms (Merritt and Maxkurtz,

1986). They are, however, in large scale use in urban areas of developing countries such as Nigeria.

Full sewerage, based on the technology of developed countries is very costly and requires expensive water resources. The development and application of alternative systems, using little or no water is therefore very important (Carroll, 1983). It is often assumed that developing countries would get used to mechanization without much difficulty. But people ignored the fact that the importance of looking after machinery and equipment was learned by the industrial world only after centuries of involvement with industrialization (Dabbha and Al-sabaqi, 1992).

Edwards (1992) reported that per capital cost for the installation of sewerage system ranges from \$150 to \$600 (1979 data). This is too expensive for most developing countries.

2.6.0 The Septic Tank

The septic tank is widely used in semi – urban areas of isolated buildings where completed sewage treatment is not feasible. It combines two processes. Sedimentation takes place in the upper portion of the tank and the accumulated sludge undergoes anaerobic decomposition which is also known as septic condition in the bottom. The digestion process results in much formation of gas as shown by anaerobic digestion cycle, and considerable scum accumulates at the surface. A baffle near the outlet keeps the scum in the tank.

The effluent coming out will still have in B.O.D. content and is also dangerous from the stand point of possible transmission of pathogenic organism. It is disposed of in soakage pit, leaching cesspool or in dispersion trench. Sludge accumulated gets digested and it is comparatively stable in nature. It is periodically cleaned and may be used as manure after further stabilization.



Septic tank may be constructed by brickwork, stone, masonry, or concrete. It should be made watertight by plastering inside with rich cement mortar in which some water proofing materials should be mixed up. The floor should be of 1:2:4: cement concrete and given a slope towards the sludge outlet. Air tight concrete or steel should be provided in the cover for the inspection and cleaning of the tank. A vent pope connected for the foul gases discharges away from the house.

Fig. shows the plan and sectional elevation of the septic tank. The length of the septic tank is kept 2 to 4 times of its width. Dimensions and positions of fixtures and fittings are kept constant as given in the figure. The Length (L), width (B) and the liquid depth (D) are to be estimated by design. The following table may give the size of the septic tank. {Chatterjee, 2005}}

Table 2.4 The Dimension of Septic Tank as per I.S. 2470 (part 1)

No of users	Length L meter	Breath B meter	Liquid depth D	Liquid capacity m ³	Free Board cm	Sludge to be removed m ³	Cleaning intervals
5	1.5	0.75	1.0	1.12	30	0.18	6 months
			1.0	1.2	30	0.36	1 year
			1.05	1.18	30	0.72	2 years
10	2	0.9	1.0	1.8	30	0.36	6 months
			1.0	1.8	30	0.72	1 year
			1.4	2.52	30	1.44	2 years
15	2	0.9	1.0	1.8	30	0.54	6 months
			1.3	2.34	30	1.08	1 year
			2.0	3.6	30	2.16	2 years

20	2.3	1.1	1.0	2.53	30	0.72	6 months
			1.3	3.3	30	1.44	1 year
			1.8	4.55	30	2.88	2 years
	4	1.4	1.0	5.6	30	1.8	6 months
			1.3	7.28	30	3.6	1 year
			2.0	11.2	30	7.2	2 years

Table 2.5: The Dimension of Large Size Septic Tank as I.S. 2470 (Part II)

<i>No of users</i>	<i>Length L M</i>	<i>Breath B M</i>	<i>Liquid D M</i>	<i>Liquid Capacity m²</i>	<i>Free board cm</i>	<i>Distance of partition wall from inlet end m</i>	<i>Cleanin g intervals years</i>	<i>remarks</i>
100	8.0	2.8	1.04	23.3	45	5.3	2	Tanks for Housin g Coloni es
150	10.6	2.7	1.15	32.9	45	7.1	2	
200	12.4	3.1	1.15	44.2	45	8.3	2	
250	14.6	3.9	1.15	65.5	45	9.7	2	
50	5	1.6	1.4	11.2	45	3.4	2	Tanks for Hostels and Boardi ng
100	5.7	2.1	1.7	20.4	45	3.8	2	
150	7.7	2.4	1.7	31.4	45	5.2	2	
200	8.9	2.7	1.7	41.0	45	6.0	2	
300	10.7	3.3	1.7	60.0	45	7.2	2	

2.6.1 The Design of Septic Tank

Details of the detention period tank and rational septic tank are treated in this section

(a) Detention Period septic tank; In the detention period, the rate of discharge by first determining the per head water consumption. The water supply may vary from 60 to 135 l.p.c.d. a figure when multiplied by the number of users gives the rate of flow. Detention periods for small size tank up to 50 users normally are assumed to be 16 to 24 hours. For bigger tanks it may be kept for 16 hours. Knowing these values the tank capacity can be computed. Then assuming the depth of flow between 1 to 2 meters, the surface area can be estimated. Fixing the length to the breadth ratio between 2 to 4, the tank dimensions can be ascertained. As a thumb rule $1/6$ to $1/5$ cu. m. volume should be provided by the user. (Chatterjee, 2005).

(a) Rational septic tank. In this method, the volume is determined separately

for (i) settling zone which is kept at a minimum depth of 30 cm, (ii) digestion zone which is provided at the rate of 0.033m^3 per capital and (iii) storage zone which is provided at the rate of $0.0021\text{m}^3/\text{capital}/\text{day}$. So its volume will depend on cleaning interval which is normally kept between 6 months to 3 years. Surface tank is provided at the rate of 8.82m^2 per 10 or less number of users. (Chatterjee, 2005).

Septic tanks are constructed with bricks, concretes or stone. The thickness of the tank should be enough so as to ensure water tightness and adequate strength. Manhole covers provided on the tank for the purpose of

inspection and dislodging purposes strong enough and of required size. In case of circular manhole covers the size of clear opening is kept 500 mm dia minimum and in case of rectangular shape it should not be less than 600×450 mm.

Every septic tank is provided with ventilation pipe at least 50 mm diameter. The top of the pipe is provided with suitable cage of mosquito proof wire mesh. The ventilating pipe should be extended to a height which would cause no smell nuisance to any building in the area. Generally the ventilating pipe may extend to a height of 2 m above the top of the building when it is located closer than 15 meters. The ventilating pipe may also be connected to the normal soil ventilating system of the building where so required.

Before the tank is commissioned for use, it should be tested for water tightness by filling it with water and allowing it for 24 hours. It should be then filled up with water and water is allowed to stand for a further 24 hours, during which time the fall in the level of water should not be more than 15 mm.

The tank preferably seeded with well digested sludge obtained from other septic tank or sludge digestion tanks. In absence of this a small quantity of decaying organic matters such as digested cow dung may be introduced (Chatterjee, 2005).

2.6.2 The Disposal of Septic Tank Effluent

The disposal of effluent tank may be done either by soil absorption or by biological filters. The construction of disposal system at the ground surface or below ground level will depend on sub – soil water level condition. When sub – soil water is within 180 cm from ground level the disposal units are constructed partly or fully above ground, otherwise sub – surface construction of this are suitable.

In case the above mentioned conditions are not feasible and where effluent has to be discharged into open drain it should be disinfected. The following are the soil absorption systems:

Soakage pit: The soakage pit is commonly known as soak pit or sometimes seepage pit. It may be of any suitable shape with the least cross – sectional dimension of 90 cm not less than 100 cm in depth below the invert level of the inlet pipe. The pit may be lined with stone, brick or concrete blocks with dry open joints which should be packed by at least 7.5 cm of clean coarse aggregate. The lining above the invert level should be finished with mortar. In case of larger dimensioned pits, the top portion may be narrowed down to reduce the size of R.C.C cover slabs. (Chatterjee, 2005).

Where no lining is provided especially near trees, the entire pit should be filled with loose stones. The inlet pit should be taken down a depth of 90 cm from the top ground level as an anti – mosquito measures. The illustration of typical soakage pit is given in fig. Soaks pits can be designed with hydraulic loading of 1000 to 1500 liters/m³/d for tank effluent.

2.6.3 Design consideration

The septic tanks will be designed like the ordinary sedimentation tanks with the following data:

- (i) **Capacity of Septic Tanks:** The volume of liquid which a septic tank can accommodate is called its capacity. A tank should be capable of storing the sewage flow during the detention period, and an additional volume of sludge for 6 months to 3 years, depending on the periodicity of cleaning. (Chatterjee, 2005).

If only water closets are connected to septic tank, the sewage flow will be about 40 – 70 liters/capital/day. Where a large quantity of sludge is expected, it

may separately be disposed off in the same manner as the effluent from the septic tank.

The sludge and the scum will accumulate in the tank at varying rates, depending upon the characteristics of raw sewage, and the efficiency of the sedimentation and digestion. The rate of accumulation of sludge has been recommended as 30 liters/person/year. The minimum capacity of a septic tank for about 8 to 10 persons, may be kept 2,250 liters (when all liquid waste are discharged into the tank) and 1,400 liters (when only water closet wastes are discharged)

- (ii) **Free – board:** A free – board of about 0.3 m may be provided above the top sewage line in the tank. This will help accommodate the scum in the tank.
- (iii) Inlet and Outlet baffles, etc. The baffles or tees should extend up to top level of the scum (about 22 cm above the top sewage line), but must stop a little below the bottom of the covering slab (by at least 7.5 cm or so) so as to allow for a free movement of gases. Moreover, the inlet should penetrate by about 30 cm below the top sewage line, and the outlet should penetrate to about 40 % of the depth of the sewage. Further, the outlet invert level should be kept 5 to 7.5 cm below the invert level.
- (iv) The Detention Period: The detention, period for septic tank generally varies between 12 to 36 hours, but is commonly adopted as 24 hours.
- (v) Length to width ratio. Septic tank is usually rectangular with their length at about 2 to 3 times width. The width should not be less than 90 cm. The depth of the tank generally ranges between 1.2 to 1.8 m. (Chatterjee, 2005).

2.6.4 Disposal of Effluent from Septic Tank

The effluent coming out from a septic tank is no better than the effluent of ordinary sedimentary tank. It contains large amount of putrescible organic matter (100 to 200 mg/l), and its BOD is quite high (100 to 200 mg/l). This

should, therefore, be disposed of carefully, so as to cause minimum nuisance or risk to the health of the people.

The following three methods of septic tank effluent are usually adopted:

- (i) Soil absorption system
- (ii) Biological filters; and
- (iii) Upflow anaerobic filters.

These methods are discussed below:

Soil Absorption System: The soil absorption system involves disposal of effluent on land, and can be adopted only when sufficient land is available and the soil is sufficiently porous as to give a percolation rate not exceeding 60 minutes.

The percolation rate of soil or a ground is defined as the time in minutes required for seepage of water through that ground by 1 cm. Higher percolation rate naturally would reflect less porous soil.

In case, sufficient porous ground is not available, the effluent of the septic tank shall be subjected to a secondary treatment either in a biological filter or in an upflow anaerobic filter, before its final disposal either in a city sewer or drain, or for gardening purposes.

The soil absorption system may be of the following two types:

- (a) Seepage pit or sack pit; and (b) Dispersion trench.

Both the above systems are explained below:

(a) **Disposal in Soak Pits**

A soak pit is a circular covered pit, through which the effluent is allowed to be soaked or absorbed into the surrounding soil. The soak pit (or sewage or sewage pit) may either be filled with stone aggregate as shown in fig. (a) Or it may be kept empty as shown in Fig. (b). When soak pit is empty, the pits is lined with brick, stone or concrete blocks with dry open joints. In addition to

this, this lining is supported below the inlet level by at least 7.5 cm thick backing of coarse aggregate, as shown below.

The lining above the inlet level should be plastered with cement mortar, as shown. However, when the soak pit is filled with stone or brick aggregate, no lining is required except for a top masonry ring constructed to prevent damage by flood of the pit by surface run off. The inlet pipe may be taken down to a depth of 0.9 m from the top as anti – mosquito measures. (Chatterjee, 2005).

For proposal in soak pits, the underground soil should be highly porous with percolation rate not exceeding 30 minutes.

2.6.5 Advantages and Disadvantages of Septic Tanks

They are enumerated as follows:

Advantages

- (i) Septic tanks can be easily constructed, and do not require any skilled supervision during construction. Moreover, there is no maintenance problem (except periodical cleaning) as there is no moving part in it.
- (ii) Their cost is reasonable compared to the advantages and sanitation they offer in rural or urban areas, where no sewage system has been laid.
- (iii) An excellent functioning septic tank can considerably reduce the suspend solids and BOD from sewage.
- (iv) The sludge volume to be disposed of is quite less, as compared to that in a normal sedimentation tank. The quantity is reduced due to digestion taking place in the tank itself. The reduction in volume is about 60%, and reduction in weight is about 30%.

- (v) The effluent from the septic tank can be disposed of on land in a soak – pit or a cesspool, without much trouble.
- (vi) They are best suited for isolated rural areas, and for isolated hospitals, buildings.

Disadvantages

- (i) If the tank is not properly functioning, which happens many a times, then the effluent will be very foul, dark, and even worst than the effluent.
- (ii) They require too large sizes for serving many people.
- (iii) Leakage of gases from the top cover of septic tank may cause bad smells and environmental pollution.
- (iv) Periodical cleaning, removal and disposal of sludge remain a tedious problem.
- (v) The working of a septic tank is unpredictable and non – uniform.

2.7.0 Internal Distribution System

It consist of a network of small diameter galvanized iron or plastic pipes with suitable fixtures at their ends. Planning of building and layout of piping should be properly done so that flow of water should be simple and pipe lengths should be minimum possible. This should both economize the construction and make equitable distribution of water. Planning will also include the sizing of each pipe. Though the total supply per day may be obtained at the rate 135 l.p.c.d supply rate from any fixture to be provided much higher.

Taps of different designs installed at places of water consumption constitute the “fixtures” pressure type or automatic closing types are used for public water supplies or public stand points. The reason for this that water will not be

wasted even due to the negligent of the people in closing the tap, Screw down bib – cocks are used in buildings so that much effort is not required for collecting water, at the same time every one is expected to take care to prevent wastage of water (Chatterjee, 2005).

2.8.0 Indicators for the Need for Sanitary Improvement

Pacey (1981) reported that UNICEF has experimented with two checklists, in India, which could help locate areas where sanitary improvement is desired. Among other things, it becomes very obvious that sanitary improvement is desired when people defecate too close to ,or at places where other people walk, or when the excreta is exposed to flies. Sanitary improvement is also desired when people defecate close to the source of drinking water or when the latrine systems are not kept clean.

Whenever there are problems of bad sanitation, with all the sicknesses and diseases that result, one may be tempted to assume that improved technology is the answer. But Pacey (1980) has discovered that technology by itself does not solve anything and that in rural areas of developing countries, it is often found that latrines, when built, are not fully used, and when used, do not always banish the diseases of bad sanitation. The essential point is that good sanitation depends primarily on people, and on how they organize hygiene-related activities.

2.8.1 The Choice of Appropriate Sanitation Technology

The choice of sanitation technology basically hangs on two factors: knowledge about each technology option, and criteria for comparing the technologies (Pacey, 1981). The process of choice can begin with an examination of an option. There will usually be some which can be excluded for

technical or social reason. Cairncross and Feachem (1983) point out those typical technical reasons for technology choice are water availability and soil conditions, particularly in area of high population density; while an example of a social reason would be the unsuitability of vietnamese composting latrines for people who use water for anal cleaning.

Once this exclusion has been made, cost comparison can be made for the remaining technologies, and some can be quickly excluded on grounds of excessive cost. (Pacey, 1980) has pointed out that the essence of the idea of appropriate technology is that equipment and techniques should be appropriate to local resources as well as to local needs. Careful appraisal of local resources and the options they represent is therefore the hallmark of any project that successfully creates an appropriate technology within a local community.

In considering what type of technology will be best, the need will usually be for equipment that is simple to assemble, does not depend on specialized imported components, and is low in cost. Also, the servicing and maintenance of the system should be relatively easy for local people to organize.

The criteria compiled for WHO by Wagner and Lanoix, and modified by Nimpuno, on the choice of appropriate sanitation technology, as reported by Pacey (1981), indicated, among other things, that: the surface soil, the ground water and surfaced water should not be contaminated. Fresh excreta should not be exposed to flies, and there should be freedom from odours. The system should be simple to operate and not too costly, and should require minimum water for operation. Also from the report of Escritt (1972), the method of treatment to be adopted should depend on

- (i) The system which will involve the minimum of running costs, including loan repayment.
- (ii) The extent to which nuisance due to flies or odour will matter.

- (iii) The area of the land available and the suitability of soil, or slope of the land, for each of the methods of treatment, and
- (iv) The degree of treatment required.

Feachem et al (1978) believed that appropriate system must be cheap, not communal, use little or none of the potable water supply for the operation, work despite misuse, require little supervision, not use soakaway, dispose of all waste water, treat the waste water to a degree where it can be discharged with little subsequent danger to users, and require no mechanical equipment. Cairncross and Feachem (1983) also observed that since the benefits of various sanitation systems cannot be quantified, the final step in identifying the most appropriate type must rest with the intended beneficiaries. Those alternatives which have survived technical, social and economic tests are best presented to the community with their attached price tags, so that users may decide what they are able and willing to pay for.

2.8.2 Influence of Social Factors on Sanitation Alternatives

Discussion of technology will only be for academic interest if people are unwilling or unable to put that technology to work. In the process of planning and development, the social factor is believed to be responsible for failure of technically sound projects (Cairncross and Feachem, 1983). Blackett (1994) has rightly observed that any sanitation project that tries to promote a technically adequate system but socially unacceptable is likely to fail.

Cairncross and Feachem (1983) have discovered that the likely effects of the various social factors on sanitation programme may be appraised, to some extent, by studying existing excreta disposal practices. According to Pacey (1981), the most important aspect of sanitation system is their acceptability by the communities concerned, and this can only be satisfactory achieved by involving the user at all stages of programme planning and implementation. The

assumptions that if the facilities were provided, people in the course of time would use them could be erroneous.

Blackett (1994) pointed out that the local used anal cleaning material usually dictates certain aspects of technical design. It is believed in some countries that sons-in-law and mother-in-law must not use the same latrine. Another of such factor is the taboo in Muslim countries against defecating while facing Mecca (Cairncross and Feachem, 1983), some of these factors can influence the technical design of the facilities, even though the factors are not scientific. For instance, for many of us, part of the proper order of things in that defecation be done in privacy. Feachem et al (1978) reported that most low-cost high density housing area in Africa were occupied by people who have moved from agricultural areas. Their behavioral pattern and habits are those of people living in a dispersed fashion where they are totally unaware of the dangers to health when living in close proximity. Consequently, they need, in general, very efficient systems which will work despite their lack of understanding.

2.8.3 Influence of Cultural Factors on Sanitation Alternatives

Very similar to social factor is influence of cultural factor on sanitation alternatives. Many rural communities have distinctive ways of organizing sanitation and hygiene, and it is part of the task of appraisal work to understand what this involves. Local hygiene culture may sometimes be a source of difficulty for a programme, but it may also present an opportunity. For example, Moslems and Hindus set a high value on cleanliness Pacey, 1981). This is an opportunity for a good sanitation programme.

The cultural practices in some communities are to provide communal facilities. But (Feachem et al, 1978) has observed that communal facilities are rarely, if ever, satisfactory, no matter what system is provided. This is because there is no individual responsibility. Once a latrine is fouled, by misuse or

accident, the next user may have no choice but to foul it further. Organization becomes critical when toilets are to be used communally. In general, if facilities must be shared between households, someone must be appointed and rewarded to look after them. This method, however, has not been known to work. Cairncross and Feachem (1983) reported that, even in Ibadan, Nigeria, with strong ethic and family ties, it has not proved possible to collect regular cash contributions for the maintenance of communal urban latrines.

If new techniques are really to be part of a people's life style, then we need to think of them as being transformed from something that is imported and alien into something that truly belongs to the local community. Another way to transform what people are already used is to upgrade the facilities gradually to the standard desired.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The project is concerned with the adequate provision of water and sanitation to churches in Akure South Local Government Area of Ondo state of Nigeria.

Ondo State is located in the South Western part of Nigeria. The state lies within latitude $5^{\circ}45'$ and $8^{\circ}15'$ North and longitude $4^{\circ}45'$ and 6° East from where Akure South Local Government Area is located at the central geographical zone (see Fig 3.1a and 3.1b).

The climatic conditions in the state follow the pattern in South Western Nigeria, where the climate is influenced mainly by the rain bearing southwest monsoon winds from the ocean and dry northwest winds from the ocean and dry northwest winds from the Sahara desert.

There are two distinct seasons, the rainy and dry seasons. The rainy season lasts for about seven months (April to October) while the dry season lasts generally from late October to March. In general terms, the state is well endowed with high rainfall with Akure south LGA measuring about 1524mm. the atmospheric temperature ranges between 28°c and 31°c and a mean annual relative humidity of about 30%.

In order to do a thorough evaluation of the subject in question Akure south LGA was further subdivided to nine geographical units taking the Deji of Akure's palace as the central location.

The preliminary study covered about 20% of churches in Akure south LGA randomly selected. To understand the need of the research, the various functions of the respective religious centers are highlighted individually. The major function of churches is primarily the place of divine worship. They play host to worshippers every Sunday of the week. In addition, large

congregations are also found in the church on other days for night vigil, bible study, revival and evangelism training service, seminar, marriages, weekly services and funeral services. Other times that the church hosts large congregation is on festive periods, like Christmas, New year, Easter celebration and other denominational programs which differ from one church to another.



Fig 3.1a: Map of Nigeria Showing Ondo State





Fig 3.1b: Map of Ondo State with the highlighted section showing Akure the study area

3.2 Method of Approach

The following methods of approach were adopted for carrying out the study to meet the objectives of the research work, outlying the following objectives.

- (i) Reconnaissance survey of the Akure metropolis were carried out in order to collate background data and location of churches.
- (ii) The physical survey of the existing water supply and toilet facilities in selected churches was carried out.

- (iii) An attitude survey by personal observations and standard questionnaire.
- (iv) The formulation of criteria for evaluation of alternative water supply and sanitation systems.
- (v) Data collection and analysis using chi – square.
- (vi) The design of prototype water supply and sanitation systems for the churches in the study area, preparation of cost estimates and comparison made to show that the facilities were not expensive considering the benefits.

3.3 Physical Survey of Existing Water Supply and Sanitation Systems in the Study Area

The selected areas of study are: Ijoka Road, Isikan Road, Oba-Adesida Road, Futa Road, and Alagbaka Road. The areas are indicated on the map of Akure in Fig 3.2.

Some of the worshippers in the churches visited were interviewed. The inspection was thoroughly carried out and photographed. Some toilet facilities in the selected churches were taken (see plate 1-6).

3.4 Administration of Questionnaire for Attitude Survey

The water supply and sanitation of facilities in randomly selected 150 churches within Akure were inspected to assess their conditions of suitability, adequacy and use by worshippers. (see Appendix 1)

A set of questionnaires (see Appendix 2) was administered on selected worshippers in each of the churches. In addition to the questionnaire administration, five members were randomly selected in each of the churches for oral interview. The questions were the same as

those on the questionnaire. The aim of the interview was to validate response given by those on whom questionnaires were administered.

3.5 Analysis of the data collected

The data collected were tested and analyzed using chi – square. The result of this analysis was used to provide a rational basis for designing workable prototype water supply and sanitation systems for the churches in the study area, at three different population levels population churches: low population churchers (up to 100 worshipers), medium population churches (up to 250 worshipers), and large population churches (up to 500 worshipers).

3.6 Design of Improved Facilities

Workable prototype water supply and sanitation facilities were designed for the three population levels. The population levels are: low population churches (up to 100 worshipers), medium population churches (up to 250 worshipers), and large population churches (up to 500 worshipers).

3.7 Cost Estimates

Cost estimates were prepared and comparison made to show that the facilities were not expensive considering the benefits. The relative locations of these facilities to the main auditorium of the churches were also evaluated to determine the optimum locations. These typical water supply and sanitation systems were designed for the different levels of user's population, and appropriately costed for comparison. (See Appendix 3)

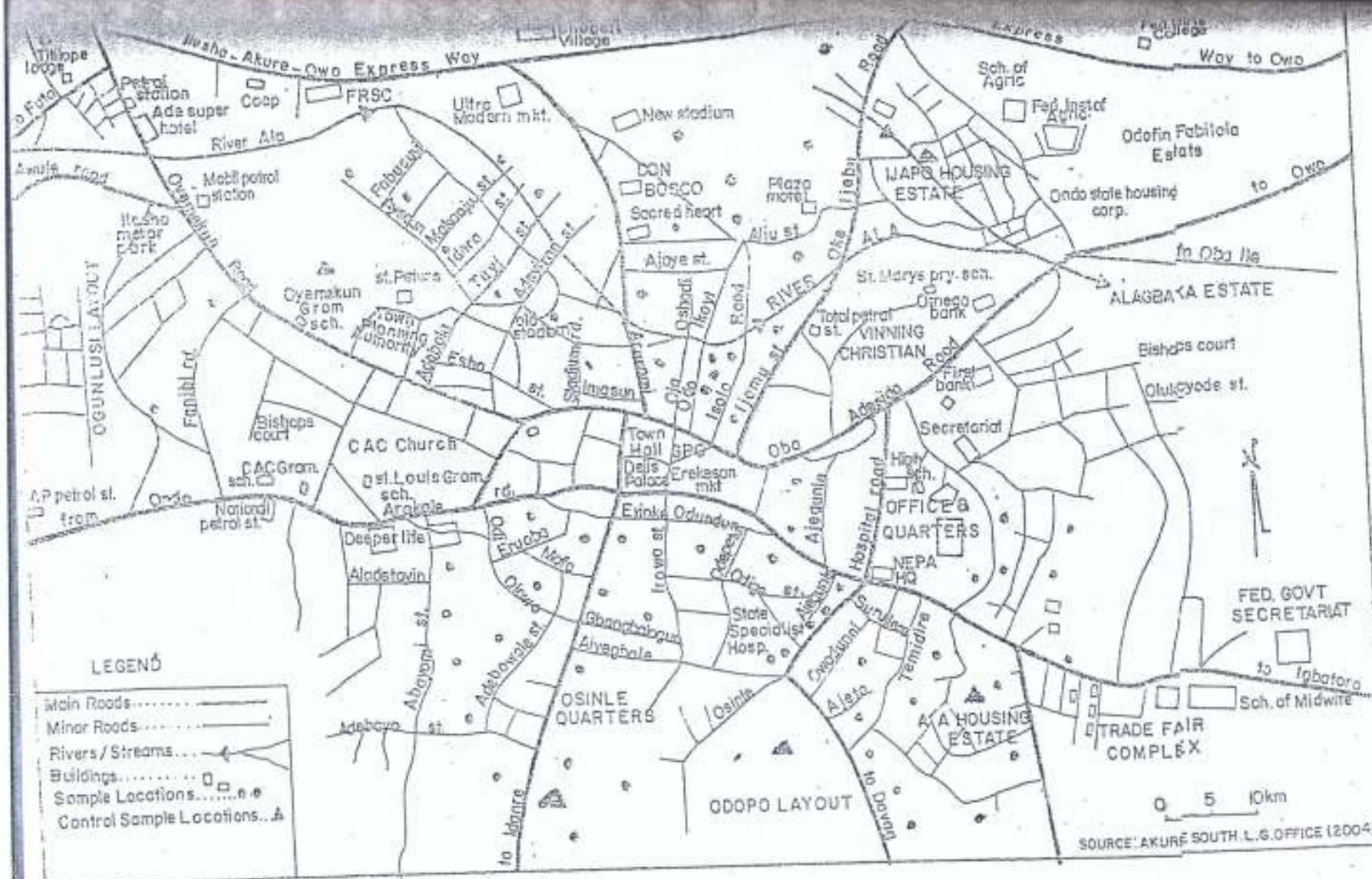


Fig.32: The Location of the Study Area.

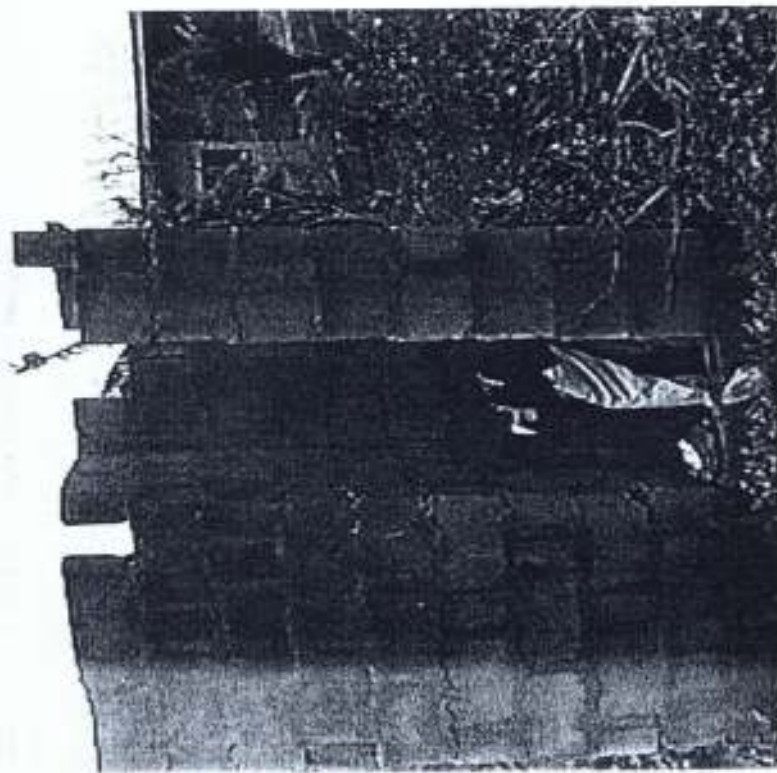


PLATE 1: SHOWING A TYPICAL PIT TOILET

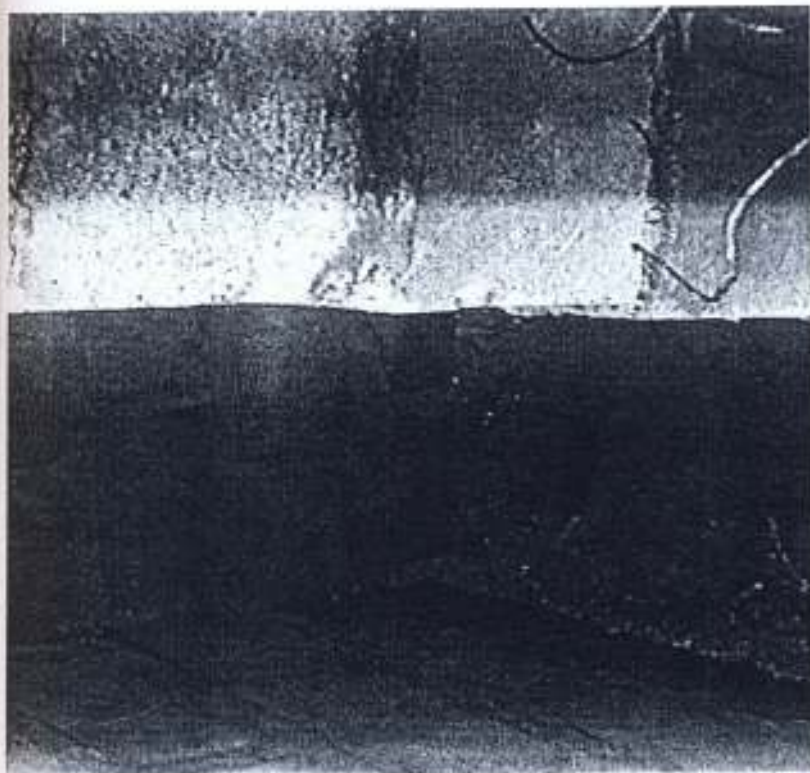


PLATE 2: SHOWING A TYPICAL PIT TOILET

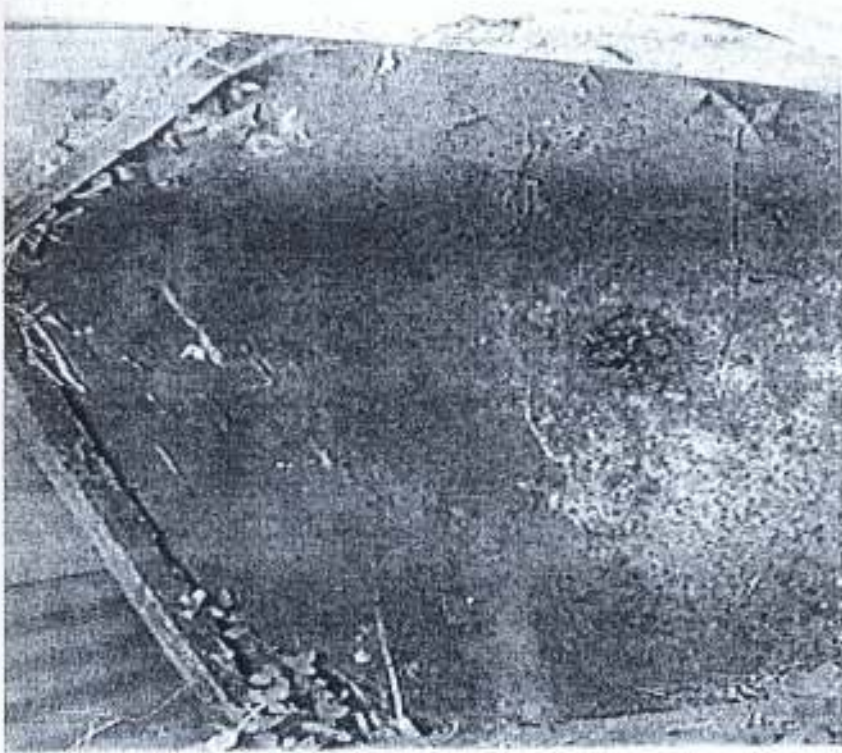


PLATE 3: SHOWING A TYPICAL PIT TOILET

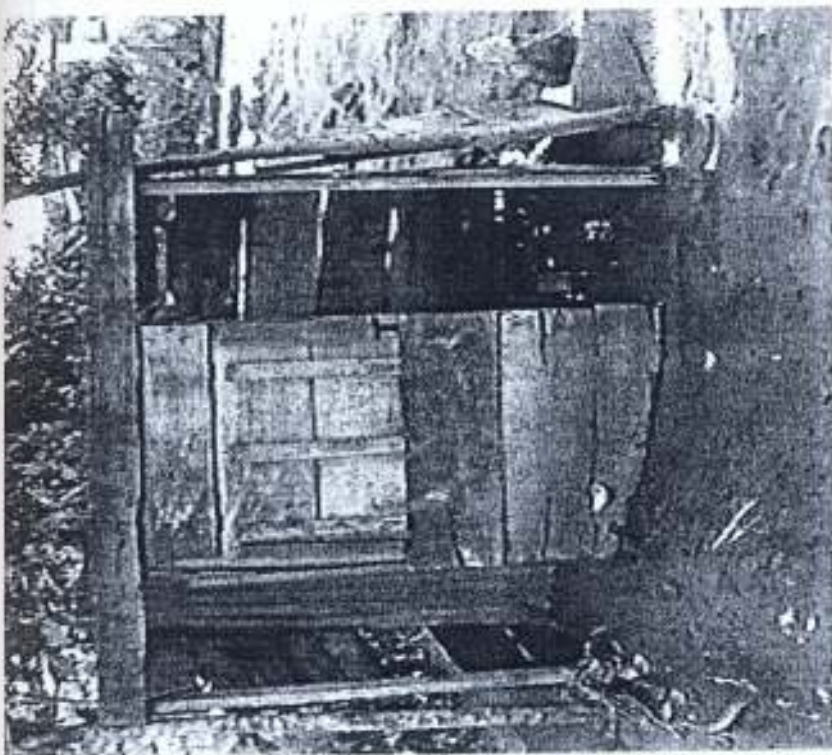


PLATE 4: SHOWING A TYPICAL PIT TOILET



PLATE 5: SHOWING A TYPICAL PIT TOILET

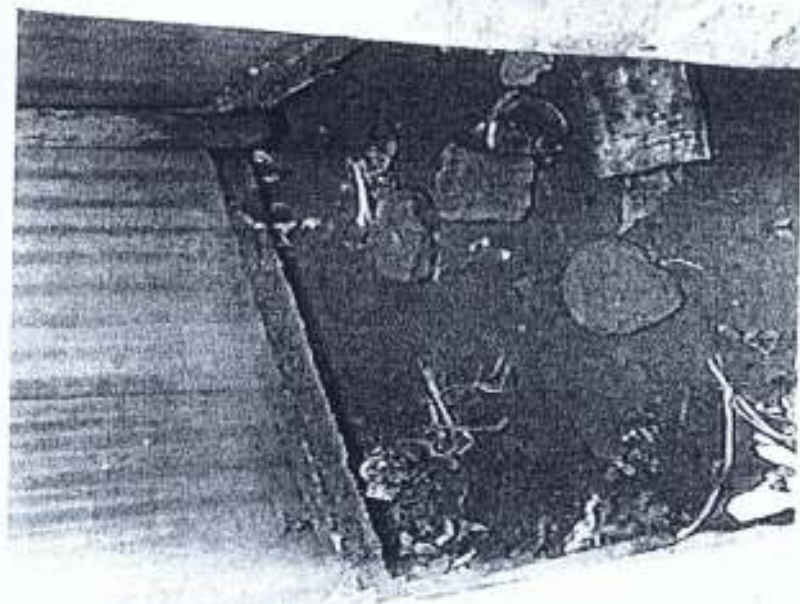


PLATE 6: SHOWING A TYPICAL PIT TOILET

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

4.1 Analysis of Data and Discussion of Result

This section of the study deals with the presentation and analysis of data collected from the physical and attitude surveys. The physical survey was carried out by personal observations and interviews, while the attitude survey was carried out by the administration of questionnaire, personal observation and interviews.

4.2 Discussion of Physical Survey carried out in the Selected Churches Septic Tank and Soakaway Systems

It was generally observed during the visit to the selected churches that the majority of the septic tanks and soakaway pits in use were poorly constructed, with majority already collapsed.

They were constructed based on the rule of thumb rather than following the engineering and architectural design standards. The same size of septic tank and soakaway used for resident building were equally used for most of these churches not taking into considerations the numbers of users of these facilities. Over half of the total facilities inspected were not planned, designed and constructed to accommodate the waste generated from the building it serves.

Moreover, most of these facilities were found to be wrongly positioned within the church premises. The location of the source of water which was majorly well water was located too close to the septic and soakaway systems.

4.3 Water supply and Plumbing Installations

It was generally observed during the survey conducted that majority of the churches were without appropriately designed and constructed ground or elevated storage tank to accommodate the water demand or water requirement

for the building it serves. The period of intermittent supply and water failure were not taken care of. Most of the plumbing systems were not adequately planned and designed before installation. The relationship of the rooms and room fixtures were not taken into consideration in the planning which made the piping arrangement cluster and also increases costs.

It was also observed that no periodic analysis of plumbing system and water supply was introduced by the church authority or governing body to ensure optimum utilization of plumbing services.

Majority of the works of the plumbing systems were not planned, designed and supervised by a competent plumber and/or a professional which made the plumbing system unreliable and hence affected the long useful life of the system.

It was equally observed that appropriate application of valves in the piping system were not placed or provided before distributing/supplying pipe enters into each unit. This made it difficult to isolate each unit for repairs and maintenance activities.

4.4 Data from Attitude Survey

This section of the study deals with the analysis of data collected from questionnaire administered to a member in each church in the selected churches in the study area.

The analysis was arranged according to the research questions.

1. supply of water to churches in the study area
2. type of toilet facility in use in the churches
3. source of water supply to the churches
4. distance of toilet from church auditorium
5. anal cleansing materials in use
6. type cleaning materials practiced

7. population of worshippers and provision of water supply
8. population of worshippers and rate of dislodge
9. toilet facility preferred
10. location of toilet facility

1. Supply of Water

The total number of respondent was one hundred and forty five for water supply through well water; a total number of 97 members (66.5%) responded that the water requirement was inadequate, while only 14 members (9.6%) responded that the water supply was adequate. For borehole supply a total number of 5 members (3.4%) responded that the water provision was inadequate, while about 25 members (17%) responded that the water provision was adequate. For pipe borne water, a total number of 2 members (1.4%) responded that the water supply was adequate while none responded that the water provision was inadequate. For tanker supply, 3 members (2%) responded that it was inadequate; only 3 members responded that they used water through tanker supply. (The adequacy and inadequacy of water supply in this Data was in terms of storage)

Table 4.1: Supply of water in the selected churches

Source	Adequate	Percentage	Inadequate	percentage	Total	Percentage
Well	14	9.58	97	66.44	111	76.00
Borehole	25	17.12	5	3.42	30	20.05
Pipe borne	2	1.37	0	0	2	1.40

Tanker supply	3	2.05	0	0	3	2.10
Total	44	30.12	102	69.86	146	100

Type of Toilet Facilities in Use

For pit latrine the total number respondents was 4 (2.74%) while the number of respondents for the use of water closet was 135 (92.44%). Only 3 members (2.05%) responded to use open field, while the remaining 4 members (2.74%) responded that they use mobile toilet.

Table 4.2: Type of toilet facility in use

Toilet facilities	No of respondent	Percentage
Pit latrine	4	2.74
Water closet	135	92.44
Open field	3	2.05
Mobile toilet	4	2.74
Total	146	100

2. Source of Water

A total number of 111 (76.03%) responded that their source of water supply was well water, while 30 (20.55%) responded that they use borehole water, 2 (1.37%) responded for the use of pipe borne water, and finally, 3 (2.05%) responded that their source of water supply is 3 (2.05%) responded that their source of water supply is through tanker.

Table 4.3: Source of Water Supply

Source	No of respondents	Percentage
Well	111	76.03
Borehole	30	20.55

Pipe borne	2	1.37
Tanker supply	3	2.05
Total	146	100

3. Distance of Toilets from the Church Auditorium

For location of the toilet facilities, 18 (12.32%) of the total respondents responded that the toilet facility was within the church auditorium, 112 (76.70%) responded that the toilet facility was located about 5 meters away from the church auditorium, 41 (28.08%) responded that the toilet facility was located about 10 meters away from the church auditorium and finally 9 (6.16%) of the respondent responded that the church auditorium was located 20 meters away from the church auditorium.

Table 4.4: Distance of Toilets from the Church Auditorium

Distance of toilets to building	Sex	Percentages
Within building	18	12.32
About 5 meters	112	76.70
about 10 meters	41	28.08
about 20 meters	9	6.16
Total	143	100

4. Preferred Location of Toilet Facilities

The number of respondent who wanted the location of the toilet facilities within the church building is 5 (3.4%), of the total respondent. A total number of 105 (71.91%) wanted if about 5 meters away from the church building, 31 (21.23%) responded that they preferred it 10 meters away none responded for 20 meters while 2 (1.37%) responded that they wanted it above 20 meters away from the church building.

Table 4.5: Table Preferred location of toilet facility

No of respondent	No of Respondent	Percentages (%)
Within building	5	3.40
about 5 meters	105	71.91
about 10 meters	31	21.23
about 20 meters	0	0
Above 20 meters	2	1.37
Total	146	100

5. Anal Cleansing Materials in Use

From the 146 (100%) who responded on anal cleaning materials, none responded to be using maize cobs, a total number of 109 (74.65%) responded to be using toilet paper, 33 (22.60%) uses water for cleaning while 4 (2.74%) uses any.

Table 4.6: Anal cleaning materials

Cleaning materials	Number of respondents	Percentage
Maize cobs	0	0
Toilet paper	109	74.65
Water	33	22.60
Any paper	4	2.74
Total	146	100

6. Type of maintenance in use

A total number of 34 (23.28%) responded that the maintenance in use is routine, 15 (10.27%) uses preventive; 96 (65.76%) uses corrective

maintenance and finally only one responded that no form of maintenance is practice in its location.

Table 4.7: Type of Maintenance in Use

Maintenance	Number of respondents	Percentages
Routine	34	23.28
Preventive	15	10.27
Corrective	96	65.76
None	1	2.68
Total	146	100

7. Population of Worshippers and Water Supply

From the data collected, the total number of respondents who had adequate water supply was 44 (30.14%) while about 102 (69.86%) had inadequate provision of water supply.

Table 4.8: Population of Worshippers and Water Supply

Average Population of worshippers	Availability of water		Total
	Adequate	Inadequate supply	
100	4	14	18
200	12	78	90
300	27	9	36
400	1	1	2
Total	44	102	146

8. Rate of Disludging

Looking at the average population of worshipper and the time of disludging the toilet system, it was analyzed that the rate of disludge in the selected churches was 3 years.

Table 4.9: Rate of Disludging

Ave. Population of worshippers	Rate of Disludge				
	Yearly	Two years	3 years	4 years	None
100	0	2	15	0	1
200	1	9	79	1	0
300	2	21	12	0	1
400	1	0	0	1	0

4.5 Testing of Hypothesis

The statistical tools used for the inference analysis is chi square(X^2) test.

Generally written as

$$\chi^2_{\text{cal}} = \sum_i^k \frac{(O-E)^2}{E}$$

Where O=Observed frequency

E=Expected frequency

K=Number of categories grouping or possible outcomes

$$E = \frac{FR \times FC}{N}$$

FR= Total row frequency

Where E = As defined above

FR=Total row frequency

Fc =Total column frequency

N =Total frequency

Moreover, the degree of freedom in a contingency table was given by

Df= Degree of freedom

R= Numbers of rows

C=Numbers of column

The hypothesis were tested, each, using the χ^2 distributions, by calculating the χ^2 value and compared with the critical value of χ^2 for the appropriate sampling distribution, as determined by the degree of freedom and the significance level.

Hypothesis I

H0: There is no relationship between the supply of water and source of water

H1: There is a relationship between the supply of water and source of water

Table 4.10: Relationship between supply of water and source of water

Source of water	Adequate	%	Inadequate	%	Total	%
Well	14	9.60	97	66.50	111	76.02
Borehole	25	17.10	5	3.40	30	20.54
Pipe borne	2	1.40	0	0	2	1.37
Tanker supply	3	2.10	0	0	3	2.05
Total	44	30.12	102	69.80	146	100

$$\chi^2_{cal} = \sum (oi - ei)^2 / ei$$

$$a_{11} = 44 \times 111 / 146 = 4884 / 146 = 33.45$$

$$a_{12} = 102 \times 111 / 146 = 11322 / 146 = 77.5$$

$$a_{21} = 44 \times 30 / 146 = 1320 / 146 = 9.04$$

$$a_{22} = 102 \times 30 / 146 = 3060 / 146 = 20.9$$

$$a_{31} = 44 \times 2 / 146 = 88 / 146 = 0.61$$

$$a_{32} = 102 \times 2 / 146 = 204 / 146 = 1.397$$

$$a_{41} = 44 \times 3 / 146 = 132 / 146 = 0.904$$

$$a_{42} = 102 \times 3 / 146 = 306 / 146 = 2.095$$

$$\chi^2 = \sum (o_i - e_i)^2 / e_i$$

$$\chi^2 = \frac{(14-33.45)^2}{33.45} + \frac{(25-9.04)^2}{9.04} + \frac{(2-0.61)^2}{0.61} + \frac{(3-0.90)^2}{0.90} + \frac{(97-77.5)^2}{77.5} + \frac{(5-2.09)^2}{2.09} + \frac{(0-1.39)^2}{1.39} + \frac{(3-2.1)^2}{2.1}$$

$$\chi^2 = 11.31 + 28.177 + 3.17 + 4.9 + 4.91 + 4.05 + 1.39 + 0.386$$

$$\chi^2_{cal} = 58.286$$

$$\chi^2_{crit} (3, 0.05) = 7.815$$

Decision Rule: Since $\chi^2_{cal} > \chi^2_{crit}$, the null Hypothesis is rejected at the 5% of level of significance.

Conclusion:

There exist a strong relationship between the source of water and adequacy of its supply. It further shows that a place of worship must determine its source of water by taking into consideration the population.

Hypothesis II

H0: Type of toilet facility is independent on the supply of water

H1: Type of toilet facility is dependent on the supply of water.

Table 4.11: Relationship between toilet facility and supply of water

Availability of water supply						
Toilet type	Adequate	%	Inadequate	%	Total	%
Pit latrine	3	2.05	1	0.6	4	2.74
Water closet system	36	24.65	99	76.8	135	92.46
Open field		1.63	1	0.6	3	2.05
Mobile toilet	3	2.05	1	0.6	4	2.74
Total	44		102		146	100

Contingency Table

3	1.205	1	2.795
---	-------	---	-------

36	40.68	99	94.315
2	1.073	1	2.096
2	1.205	1	2.795
O _i	E _i 's	O _i	E _i

$$\chi^2_{\text{cal}} = 2.674 + 0.538 + 0.801 + 2.674 + 1.153 + 0.233 + 0.573 + 1.153$$

$$\chi^2_{\text{cal}} = 9.799$$

$$\chi^2_{\text{crit}} (3, 0.05) = 7.815$$

Decision Rule:

Reject the null hypothesis if $\chi^2_{\text{cal}} > \chi^2_{\text{crit}}$

Conclusion:

Since, the $\chi^2_{\text{cal}} > \chi^2_{\text{crit}}$ we have the statistical reason to reject the null hypothesis and conclude that type of toilet facility is dependent on the water supply at the 5% significant level.

Hypothesis III

H₀: The population of worshippers is independent on the toilet facilities provided

H₁: The population of worshippers is dependent on the toilet facilities provided

Table 4.12: Relationship between populations of worshippers against toilet facilities

Population	Toilet Facilities				Total
	pit latrine	water closet	open field	mobile toilet	
100	1	17	0	0	18
200	2	86	1	1	90
300	1	30	2	3	36
400	0	2	0	0	2
	4	135	3	4	146

Contingency Table

O	E	O	E	O	E	O	E
1	0.49	17	16.65	0	0.37	0	0.49
2	2.47	86	83.22	1	1.85	1	2.47
1	0.99	30	33.29	2	0.74	3	0.99
0	0.06	2	1.85	0	0.05	0	0.06

$\chi^2_{cal} = 9.2963$ but,
 $\chi^2_{crit}(9, 0.05) = 16.919$

Decision Rule:

Reject the Null hypothesis $\chi^2_{cal} > \chi^2_{crit}(9, 0.05)$, otherwise do not reject the null Hypothesis.

Conclusion:

Since the $\chi^2_{cal} < \chi^2_{crit}(9, 0.05)$, we have the statistical reason not to reject H_0 and we conclude the population of worshippers is independent of the toilet facilities.

HYPOTHESIS IV

H_0 : The rate of dislodge is independent of the population of worshippers

H_1 : The rate of dislodge is dependent on the population of worshippers

Table 4.13: Relationship between populations of worshippers against rate of dislodge

Population of worshippers	Rate of Dislodge					Total
	Yearly	2 years	3 years	4 years	None	
100	0	2	15	0	1	18
200	1	9	79	1	0	90

300	2	21	12	0	1	36
400	1	0	0	1	0	2
Total	4	32	106	2	2	146

Contingency Table

O	E	O	E	O	E	O	E	O	E
0	0.493	2	3.945	15	13.068	0	0.247	1	0.247
1	2.466	9	19.726	79	65.342	1	1.233	0	1.233
2	0.986	21	7.89	12	26.137	0	0.493	1	0.493
1	0.054	0	0.438	0	1.452	1	0.027	0	0.027

$\chi^2_{cal} = 100.158$ but,
 $\chi^2_{crit}(15, 0.05) = 24.996$

Decision Rule:

Reject the H_0 if the $\chi^2_{cal} > \chi^2_{crit}(15, 0.05)$ otherwise we do not reject H_0 .

Conclusion:

Since the value of the $100.158 > 24.996$ we have the statistical reason to reject the H_0 and conclude that at 5% level of significance the rate of dislodge is dependent on the population of worshippers.

Hypothesis V

H_0 : The adequacy of toilet facilities is independent of site ownership

H_1 : The adequacy of toilet facilities is dependent on the site ownership

Table 4.14: Relationship between adequacy of toilet facilities and site ownership

Site Ownership	Adequacy of toilet facilities		Total
	Adequate	Inadequate	
On lease	20	95	115
Permanently acquired	24	7	31
Total	44	102	146

Contingency Table

O	E	O	E
20	34.6	95	80.3
24	9.34	7	21.6

$$\chi^2_{\text{cal}} = 38.9$$

Note that for a 2x2 contingency table we use a correction factor, thus the formulae is

$$\chi^2_{\text{cal}} = \sum (|o_i - e_i| - 0.5)^2 / e_i$$

$$\chi^2_{\text{cal}} = 38.9 \text{ but,}$$

$$\chi^2_{\text{crit}}(1, 0.05) = 3.841$$

Decision rule:

Reject H_0 if $\chi^2_{\text{cal}} > \chi^2_{\text{crit}}(1, 0.05)$ otherwise do not reject H_0 .

Conclusion:

Since $38.9 > 3.841$, we have the statistical reason to reject the null hypothesis and we conclude that we are 95% certain that the adequacy of toilet facilities is dependent on the site ownership.

Hypothesis VI

H_0 : Toilet facility is independent of site ownership

H_1 : Toilet facility is dependent on site ownership

Table 4.15: Relationship between toilet facility and site ownership

Site ownership	Type of Toilet facility				Total
	Pit latrine	Water closet	Open field	Mobile toilet	
Lease	3	108	2	2	115
Perm. Acquired	1	27	1	2	31

Total	4	135	3	4	146
-------	---	-----	---	---	-----

Contingency table

O	E	O	E	O	E	O	E
3	3.15	108	106.3	2	2.36	2	3.15
1	0.849	27	28.66	1	0.636	2	0.849

$$\chi^2_{\text{cal}} = 9.533$$

$$\chi^2_{\text{crit}}(3, 0.05) = 7.815$$

Decision Rule:

Reject H_0 if $\chi^2_{\text{cal}} > \chi^2_{\text{crit}}(3, 0.05)$, otherwise do not reject the null hypothesis

Conclusion:

Since $9.533 > 7.815$ we have the statistical reason to reject H_0 and we conclude that the type of toilet facility provided is dependent on the site ownership.

4.6 Design of water storage tank for three population levels:

4.6.1 Design of water storage tank for low population churches(up to 100 worshippers)

From the architectural design standard

30 users/ toilet facility is recommended

Assume water closet flushing/ capital/day(worship service) = 12 liters

For washing hands: 3 liters per/capital/(worship services) is assumed.

Consumption per capital/ worship services = 15 liters (Chatterjee, 2005)

15% waste and contingencies = 2 liters

Assumption: 60% of the population assumed to use the toilet facilities/worship services. (From architectural design standard)

Hence, total consumption = 17 liters $\times$ 60 = 1020 liters.

If there is water failure for 5 days

The storage tank capacity = 5 $\times$ 1020 liters = 5.1m³

Optimum size of storage tank with a capacity of 5.5m³ is recommended for 100 worshippers.

4.6.2 Design of water storage tank for medium population churches(between 100- 500 worshippers)

For 250 users, it is assumed that 60% of this population will use the toilet facility per worship service. Assuming a 60% population using the facility during worship service, then the total number of people to use the toilet facility 150.

Hence, a total population of 150 is used as a basis for the provision of water storage tank.

Total consumption = 150 $\times$ 17 litres = 2,550 litres

It has been observed that water supply sometimes fail for 5 days or even more, therefore, storage tank of 5 $\times$ 2,550 litres = 12, 750 litres is required.

An optimum size of storage tank with a capacity of 13m³ is recommended for 250 worshippers.

4.6.3 Design a water storage tank for large population churches(above 500 worshippers)

Assuming the usage population to be 300/day a 60 population, the total number of people to use the toilet facility per day is 300.

Total consumption = 300×17 litres = 5,100 litres per day.

It has been observed that water supply sometimes fail for 5 days or even more.

Therefore, storage capacity = $5 \times 5,100 = 25,500$ litres.

An optimum size of 2.1m $\times$ 3.5m $\times$ 3.5m rectangular tank is recommended as shown below:

4.7 Design of a septic tank

4.7.1 Design a septic tank for low population churches(up to 100 worshippers)

From the design of water supply facility for 100 users, the average daily consumption per head is 17 litres.

The quantity of water supplied.

= per capital rate $\times$ population.

= 100×17 litres/day = 1,700 l/day.

Assuming the 80% of water supplied becomes sewage, (Chatterjee, 2005)

We have,

The quantity of sewage produced.

= $1,700 \times 0.8 = 1,360$ l/day.

Assuming the detention time to be 24 hours, we have,

The quantity of sewage produced during the detention period (i.e. the capacity of the tank)

= $1,360 \times 24/24 = 1,360$ litres.

Now assuming the rate of deposited sludge as 30 litres/capital/year; and also assuming the period of clearing as 3 years, we have: (Chatterjee, 2005)

The volume of sludge deposited

$$= 30 \times 100 \times 3 = 9,000 \text{ litres.}$$

The total required capacity of the tank.

$$= \text{capacity for sewage} + \text{capacity for sludge.}$$

$$= 1,360 + 9,000 = 10,360 \text{ litres} = 10.36 \text{ cu.m}$$

Assuming 1.5m as the depth of the tank, we have the surface of the tank

$$= (10.36/1.5) \text{ m}^2 = 6.9 \text{ m}^2$$

If the ratio of the length to width is kept as

3:1, we have,

$$3: B^2 = 6.9.$$

$$B = \sqrt{6.9/3} = 1.5 \text{ m}$$

Provided width = 1.5m; and

Provided length of the tank = 4.5m

Area of cross-section provided.

$$= 4.5 \times 1.5 = 6.75; \text{ say } 6.8 \text{ m}^2.$$

Thus, the dimension of the septic tank will be,

4.5m $\times$ 1.5m $\times$ (1.5 + 0.3)m overall depth (0.3m used as free – board).

Hence, use a tank of size 4.5m $\times$ 2.1m $\times$ 1.8m.

4.7.2 Design of septic tank for medium population churches (between 100- 500 worshippers)

The average daily consumption per head is 17 litres.

The quantity of water supplied

$$= \text{per capital rate} \times \text{population}$$

$$= 250 \times 17 \text{ litres/day} = 4250 \text{ l/day}$$

Assuming that 80% of water supplied becomes sewage,

We have:

The quantity of sewage produced

$$= 4250 \times 0.8 = 3400 \text{ l/day.}$$

Assuming the detention time to be 24 hours, we have,

The quantity of sewage produced during the time of detention period
(i.e. capacity of the tank)

$$= 3,400 \times 24/24 = 3,400 \text{ litres.}$$

Now assuming the rate of deposited sludge as 30 litres/capital/year and also assuming the period of clearing as 3 years, we have:

The volume of sludge deposited.

$$= 30 \times 250 \times 3 = 22,500 \text{ litres.}$$

Total required capacity of the tank.

= capacity for sewage + capacity for sludge.

$$= 3,400 + 22,500 = 25,900 \text{ litres} = 25.9 \text{ cu.m}$$

Assuming 1.5m as the depth of the tank, we have,

$$\text{The sludge area of the tank} = (25.9/1.5) \text{ m}^2 = 17.27 \text{ say } 17.3 \text{ m}^2$$

If the tank ratio of the length to width is kept as 2:1, we have,

$$2:B^2 = 17.3$$

$$B = 17.3/2 = 8.65 = 2.94 \text{m say } 3 \text{m}$$

Provide width = 3m

Provide length of the tank = 6m

Area of the cross – section provided 18 m^2

$$= 6 \text{m} \times 3 \text{m} = 18 \text{ m}^2$$

Thus, the dimension of the septic tank will be

$$= 6 \text{m} \times 3 \text{m} \times (1.5 + 0.3) \text{m overall depth. (0.3m used as free –}$$

board)

Hence, use a tank of size $6\text{m} \times 3\text{m} \times 1.8\text{m}$

4.7.3 Design a septic tank for large population churches (above 500 worshippers)

From the design of water supply facilities for 500 users the average daily consumption per head is 17 litres.

The quantity of water supplied = per capital rate $\times$ population.

$$= 500 \times 17 \text{ litres/day} = 8,500 \text{ l/day.}$$

Assuming that 80% of water supplied becomes sewage, we have,

The quantity of sewage produced,

$$= 8,500 \times 0.8 = 6,800 \text{ litres/day.}$$

Assuming the detention time to be 24 hours, we have,

The quantity of sewage provided during the detention period (i.e. the capacity of the tank)

$$= 6,800 \times 24/24 = 6,800 \text{ litres.}$$

Now assuming the rate of deposited sludge as 30 litres/capital/year; and also assuming the period of cleaning as 2 years, we have,

The volume of sludge deposited.

$$= 30 \times 500 \times 2 = 30,000 \text{ litres.}$$

Total required capacity of the tank.

= capacity for sewage + capacity for sludge.

$$= 6,800 + 30,000 = 36,800 \text{ litres} = 36.8 \text{ cu.m}$$

Assuming 1.5m as the depth of the tank, we have,

The surface area of the tank,

$$= (36.8/1.5) \text{ m}^2 = 24.5\text{m}^2$$

If the ratio of the length to width is kept as,

2:1, we have,

$$2:B^2 = 24.5$$

$$B = \sqrt{24.5/2} = 12.25 = 13.5\text{m}$$

Provide with = 3.5m

Provide length of the tank = 7m.

Area of the cross – section provided.

$$= 7\text{m} \times 3.5\text{m} = 24.5\text{m}^2$$

Thus, the dimension of the septic tank will be

7m × 3.5m × (1.5 + 0.3)m overall depth (0.3m used as the free – board)

Hence, use a tank of the size 7m × 3.5m × 1.8m

4.8 Soak-away pit

Generally, $A = NQ/I$

A = Infiltration area (m^2)

N = Population

Q = Waste flow (l/h/d)

I = Infiltration rate ($\text{l/m}^2/\text{d}$)

For a lining population of 30 people per facility at the infiltration rate of 50 $\text{l/m}^2/\text{d}$. 75% of water used as a waste.

$$A = 30 \times 75/50 \times 100$$

$$= 0.45\text{m}^2$$

Provide

$$L = 1.5\text{m}$$

$$B = 1.2\text{m}$$

$$\text{Dimension} = (1.5 \times 1.2)\text{m} = 1.8\text{m}^2$$

Height of excavation

$$\text{Use } h = 1.2\text{m}$$

Free space = 0.3m

Excavation height = $1.2 + 0.3 = 1.5\text{m}$

Excavation dimension = $1.5\text{m} \times 1.2\text{m} \times 1.5\text{m}$.

PROBLEMS OF SEPTIC TANK DESIGNS/SOAKAWAY

Most septic tanks and soakaway pits designed for public buildings are of poor standards. In most of the public institutions, it is obvious that:

- (i) The same size of septic tank/soakaway pit used for the public institutions such as worship centres were also used for private buildings not taking into consideration the number of users and the years of disludging.
- (ii) Most of the septic tank/soakaway wells were wrongly located within the premises of the worship centres. The location of sources of water supply which is mainly well water were too close to the septic tank and soakaway. The minimum distance should be about 12 meters.
- (iii) There was no visible access to the facility for the disludging.
- (iv) Some of the locations of septic tank made it impossible for the minimum depth and the required gradient to be achieved during the construction.

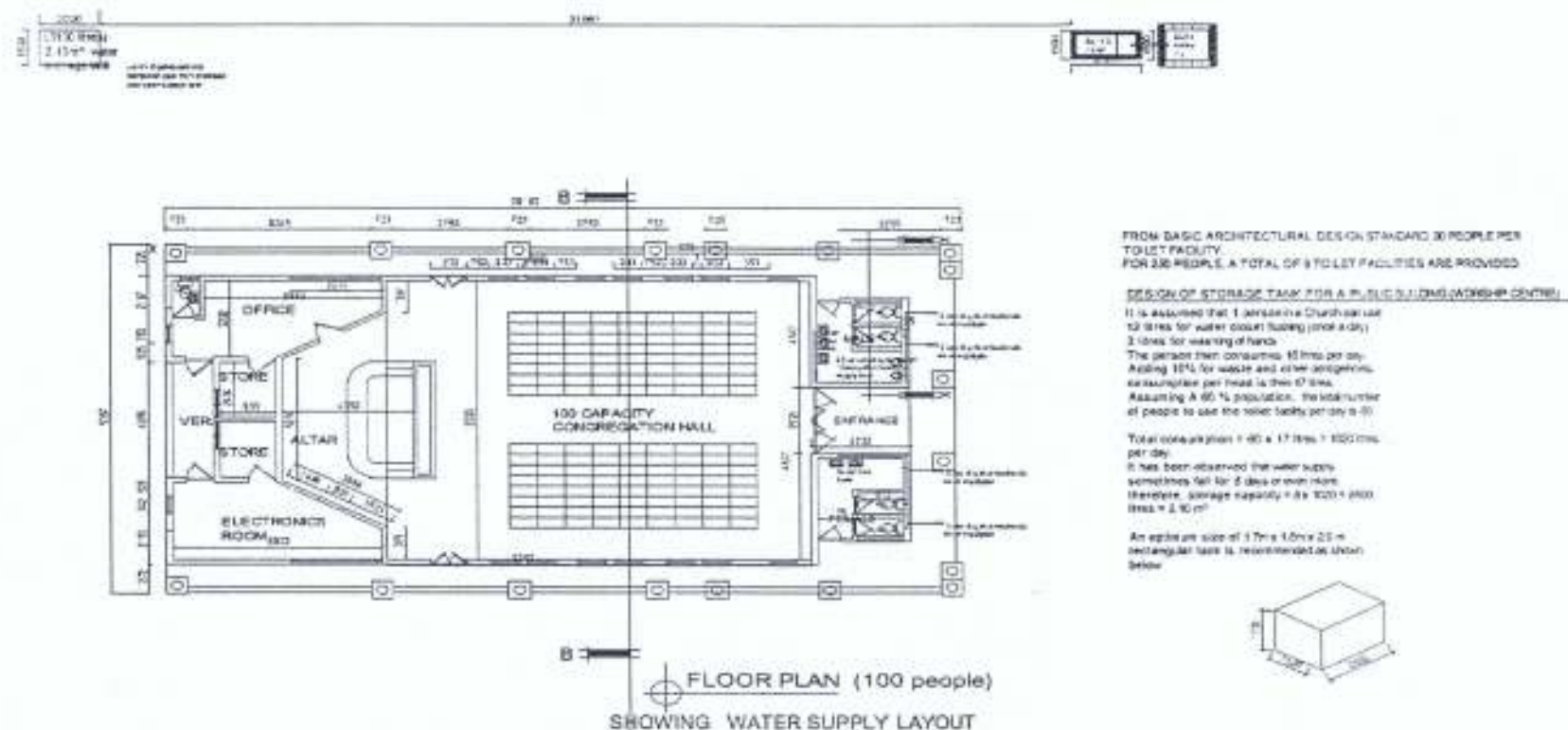
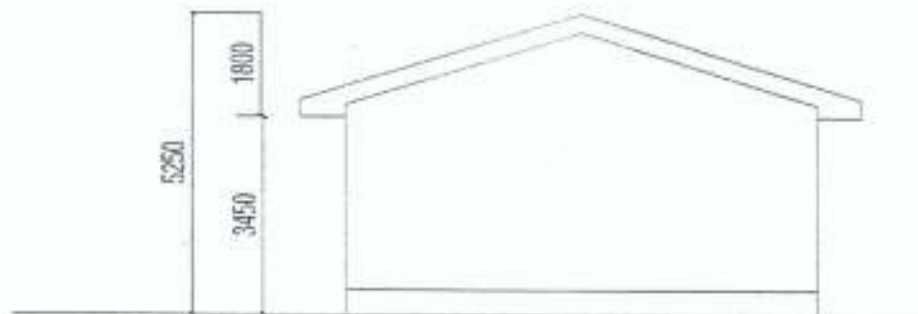


Fig. 4.1: Floor plan showing soil/waste water layout (Attached) for 100 users



FRONT ELEVATION



TYPICAL
SIDE
ELEVATION

Fig.4.2: Floor plan showing toilet and water supply layout (Attached) for 100 users

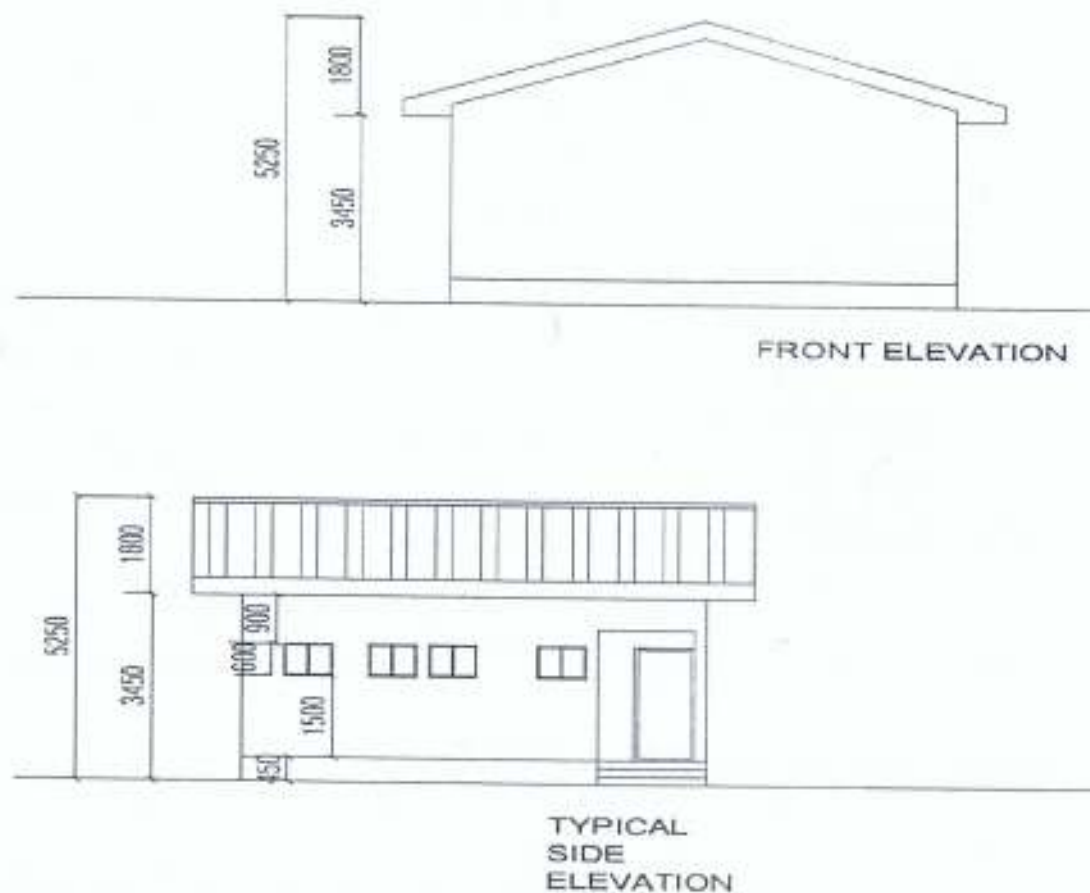


Fig. 4.3: Drawing showing front elevation and typical side elevation and facilities for 250 users

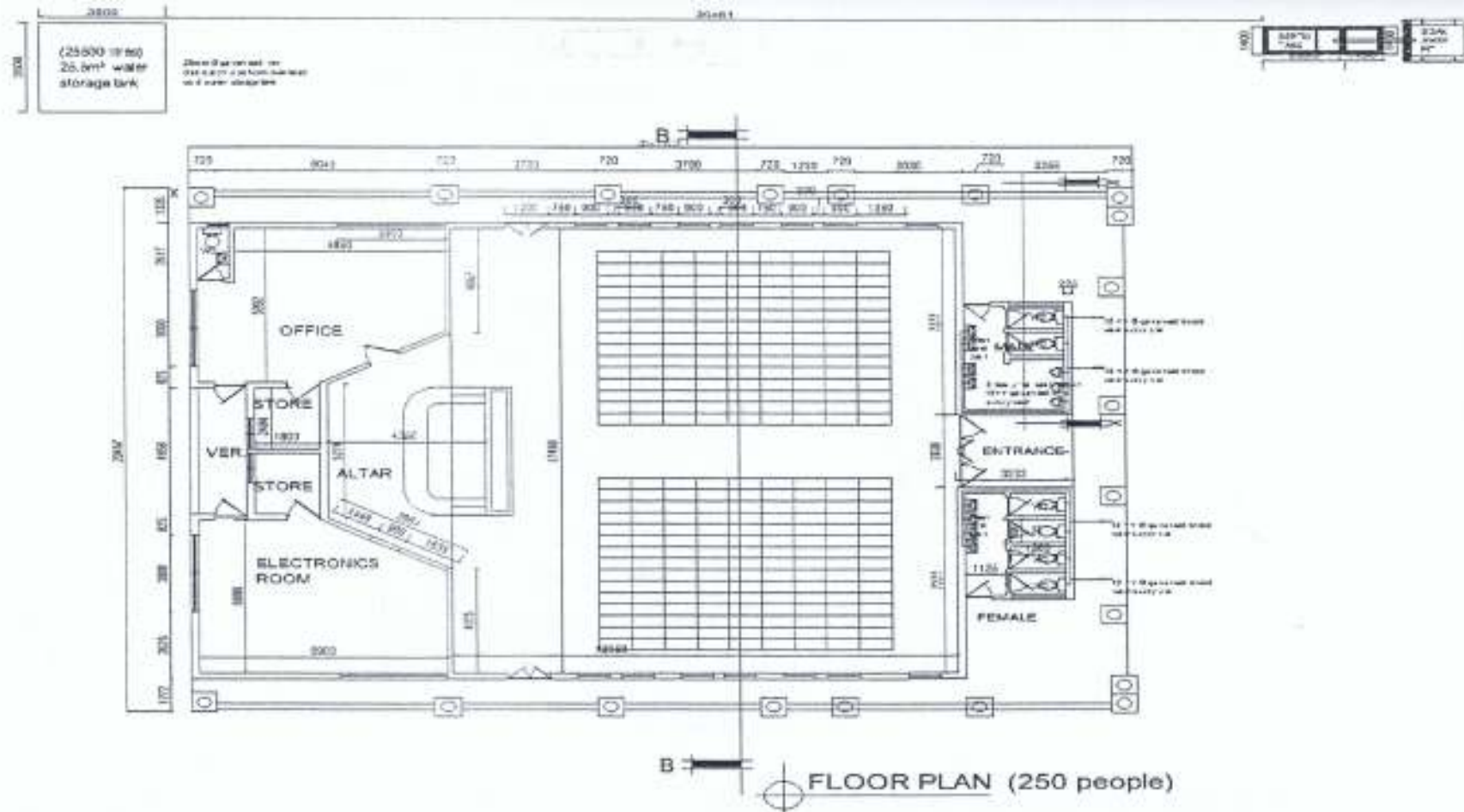
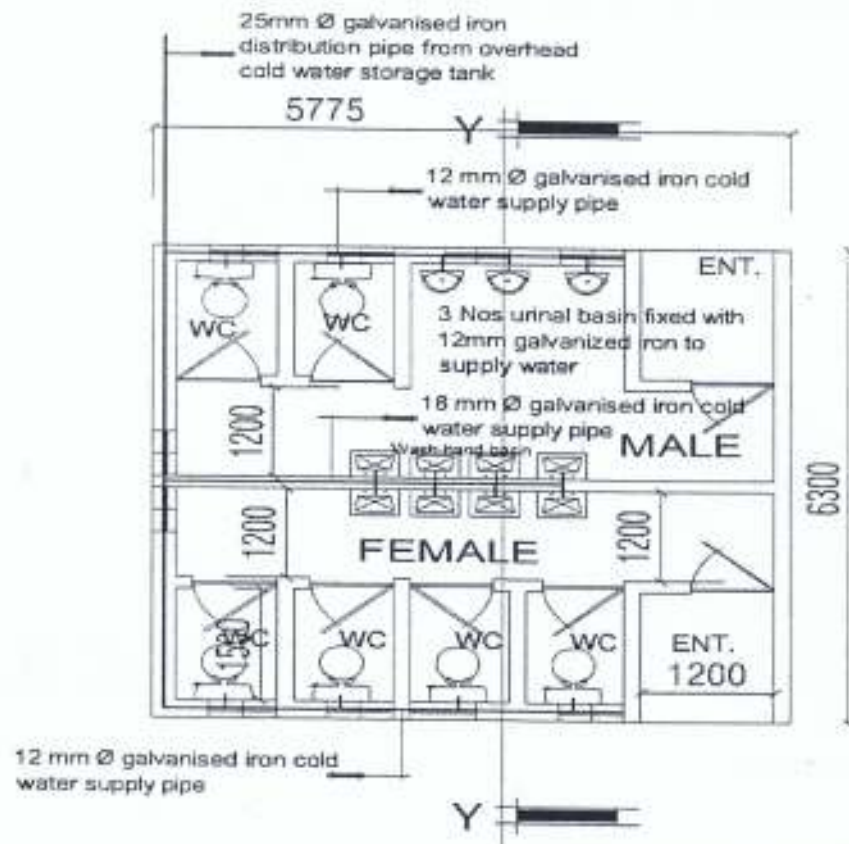


Fig.4.4: Floor plan showing soil/waste water layout (Attached) for 250 users



**FLOOR PLAN
SHOWING WATER SUPPLY LAYOUT**

Fig.4.5: Floor plan showing toilet and water supply layout (Attached) for 250 users

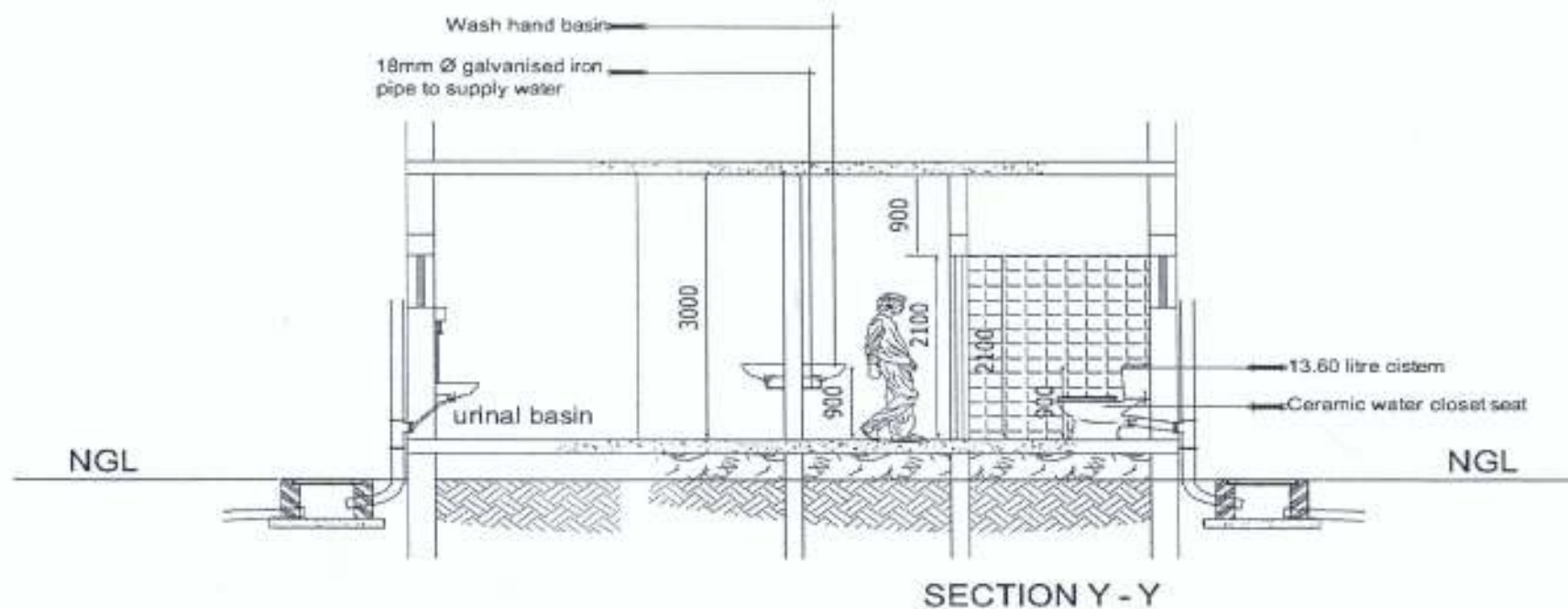


Fig.4.6: Drawing showing section Y-Y for toilet facilities (Attached) for 250 users

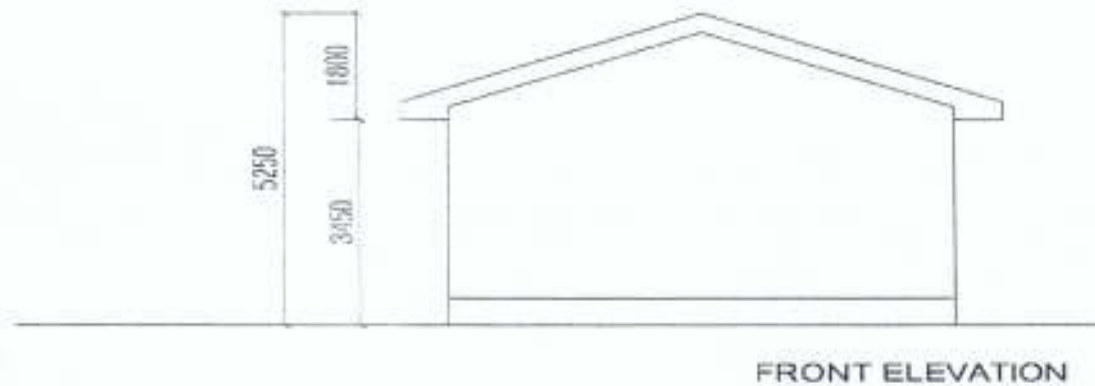


Fig.4.7: Drawing showing front elevation and typical side elevation and facilities (Attached) for 250 users

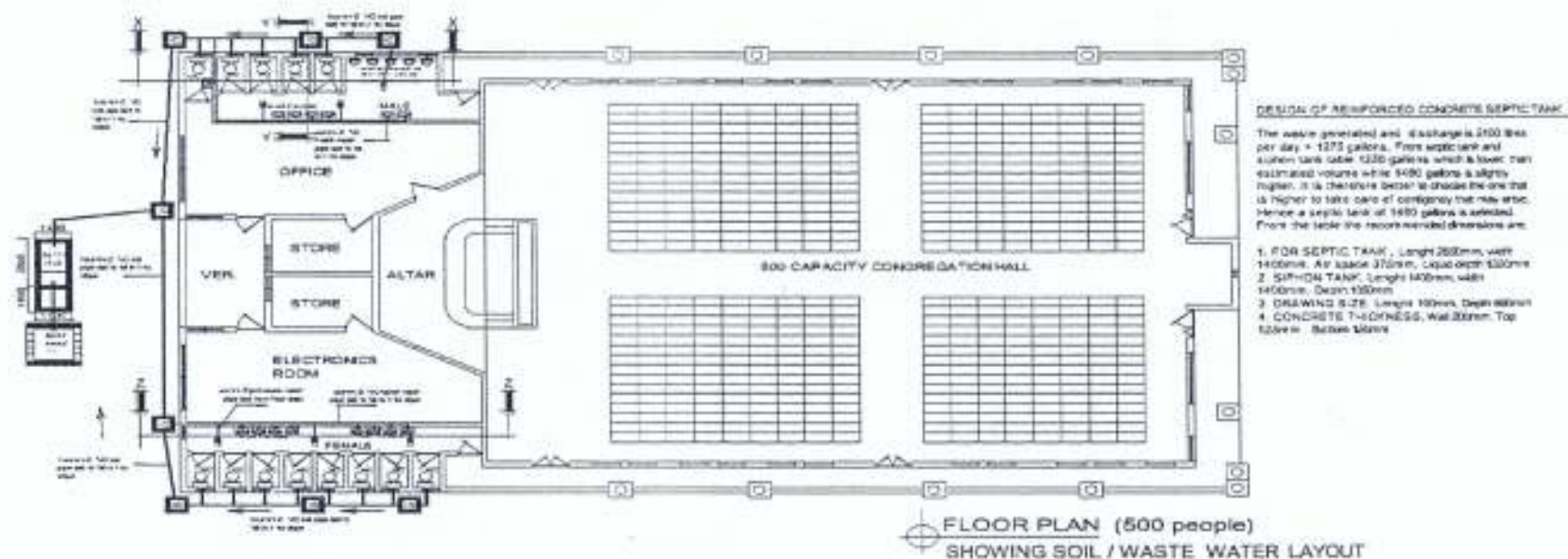


Fig.4.8: Floor plan showing soil/waste water layout (Attached) for 500 users

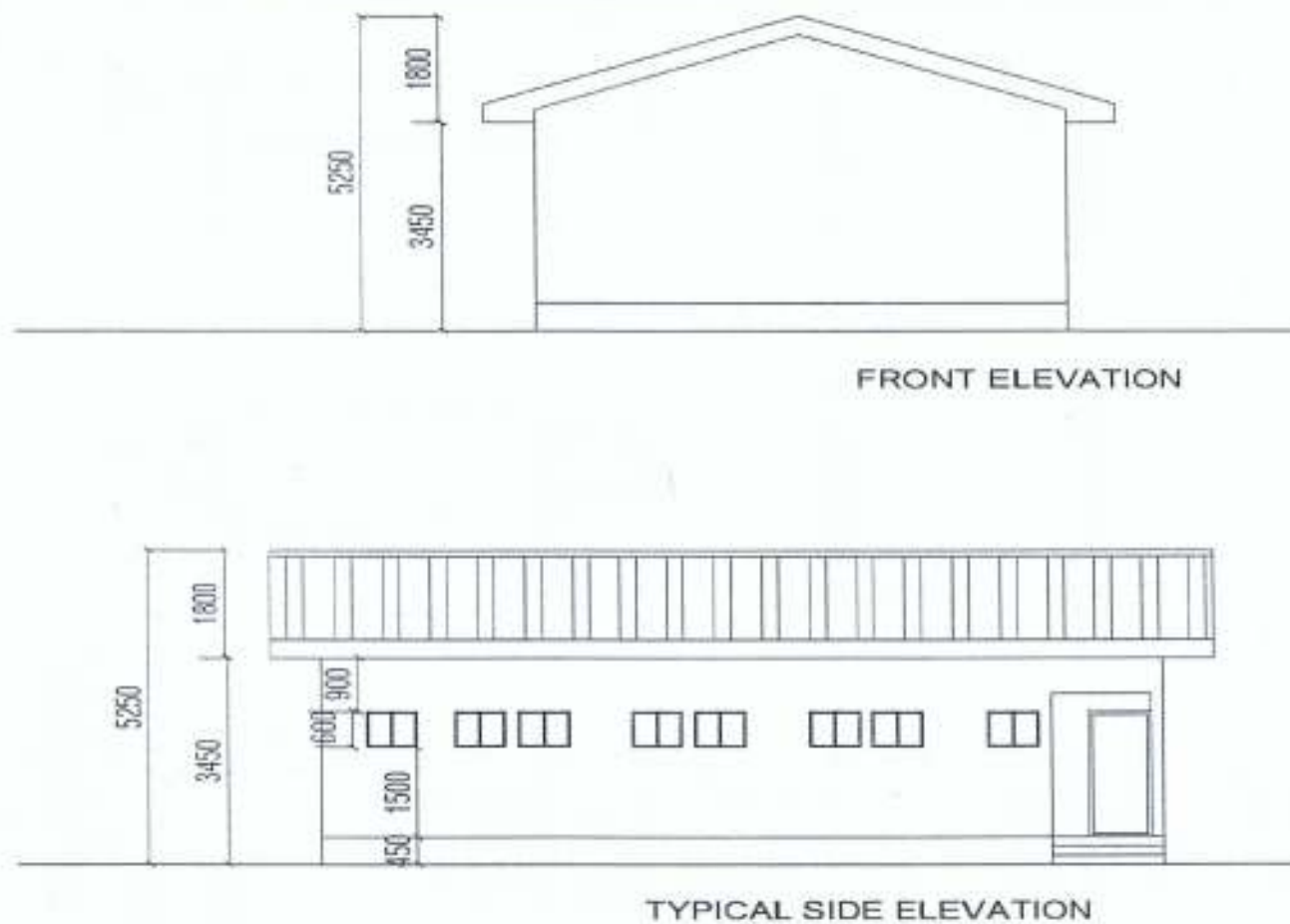


Fig.4.11: Drawing showing front elevation and typical side elevation and facilities (Attached) for 500 users

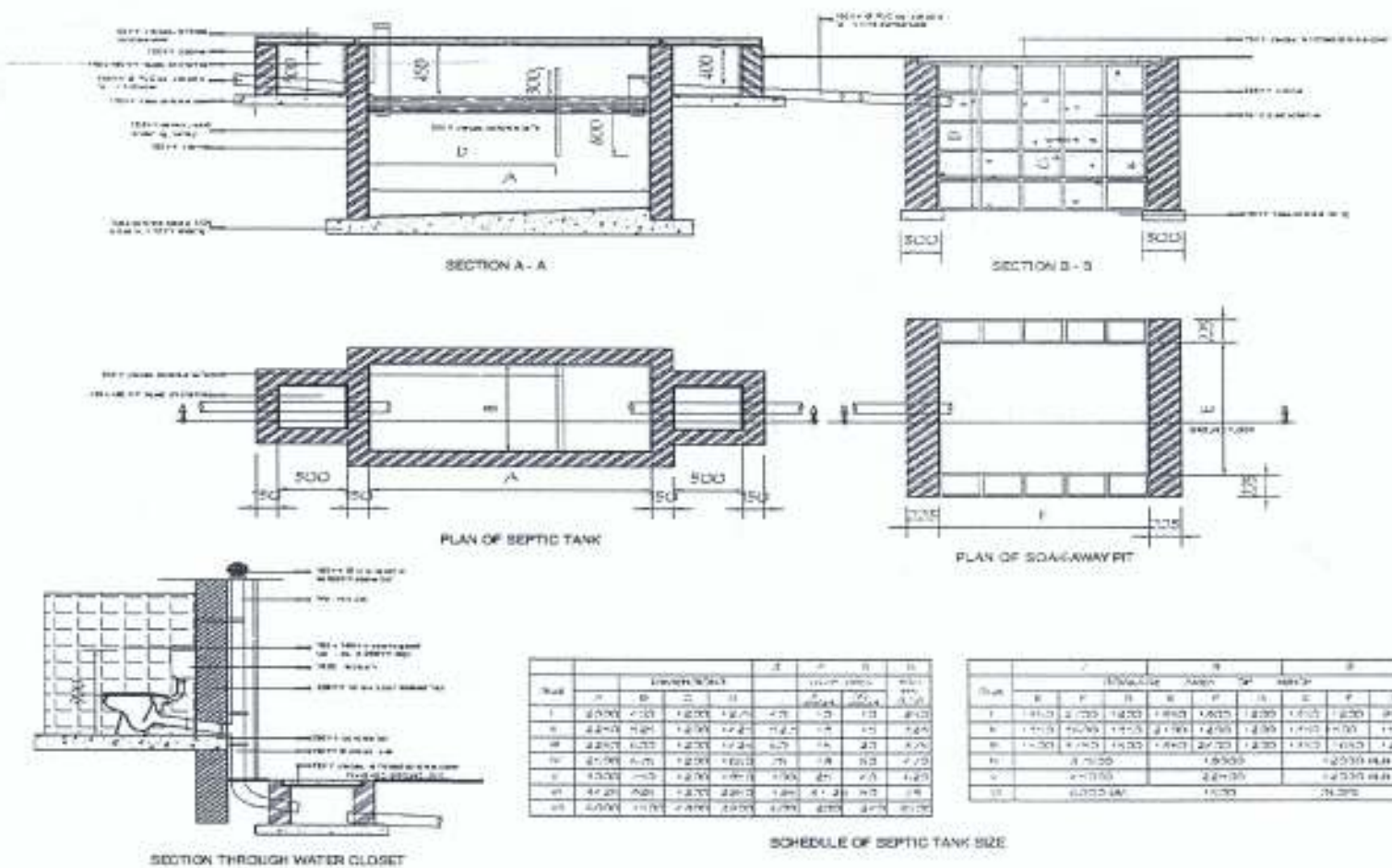


Fig.4.12: Drawing showing the plan of septic tank, soak-away pit, section through water closet and schedule of septic tank size

Bill No 001

Table 4.16 Summary of cost estimates for a typical, detached toilet building, toilet facilities and water supply for 100 users

S/N	ELEMENTS	COSTS
1.	Substructure	464,255.00
2.	Roof	331,240.00
3.	Walls	262,500.00
4.	Windows	69,025.00
5.	Doors	219,400.00
6.	Finishes	566,500.00
7.	Painting and Decoration	86,350.00
8.	Services	369,000.00
9.	Septic tank/soakaway	270,550.00
	Grand Total	2,638,820.00

Bill No 002

Table 4.17: Summary of cost estimates for a typical, detached toilet building, toilet facilities and water supply for 250 users

S/N	ELEMENTS	COSTS
1.	Substructure	505,040.00
2.	Roof	362,900.00
3.	Walls	283,500.00
4.	Windows	85,500.00
5.	Doors	275,000.00
6.	Finishes	622,750.00
7.	Painting and Decoration	93,100.00
8.	Services	490,500.00
9.	Septic tank/soakaway	398,600.00
	Grand Total	3,116,890.00

Bill No 003

Table 4.18: Summary of cost estimates for a typical, detached toilet building, toilet facilities and water supply for 500 users

S/N	ELEMENTS	COSTS
1.	Substructure	815,615.00
2.	Roof	542,000.00
3.	Walls	436,800.00
4.	Windows	132,025.00
5.	Doors	467,300.00
6.	Finishes	1,013,200.00
7.	Painting and Decoration	138,600.00
8.	Services	770,000.00
9.	Septic tank/soakaway	498,300.00
	Grand Total	4,813,840.00

Bill No 003

Table 4.18: Summary of cost estimates for a typical, detached toilet building, toilet facilities and water supply for 500 users

S/N	ELEMENTS	COSTS
1.	Substructure	815,615.00
2.	Roof	542,000.00
3.	Walls	436,800.00
4.	Windows	132,025.00
5.	Doors	467,300.00
6.	Finishes	1,013,200.00
7.	Painting and Decoration	138,600.00
8.	Services	770,000.00
9.	Septic tank/soakaway	498,300.00
	Grand Total	4,813,840.00

Bill No 004

Table 4.19: Summary of cost estimates for a typical, attached toilet building, toilet facilities and water supply for 100 users.

S/N	ELEMENTS	COSTS
1.	Substructure	404,735.13
2.	Roof	288,773.33
3.	Walls	228,846.15
4.	Windows	60,175.64
5.	Doors	191,271.79
6.	Finishes	493,871.79
7.	Painting and Decoration	75,279.49
8.	Services	321,692.31
9.	Septic tank/soakaway	235,864.10
	Grand Total	2,300,509.74

Bill No 005

Table 4.20: Summary of cost estimates for a typical, attached toilet building, toilet facilities and water supply for 250 users

S/N	ELEMENTS	COSTS
1.	Substructure	422,824.19
2.	Roof	303,823.26
3.	Walls	237,348.84
4.	Windows	71,162.79
5.	Doors	230,232.56
6.	Finishes	521,372.09
7.	Painting and Decoration	77,944.19
8.	Services	410,651.16
9.	Septic tank/soakaway	333,7111.63
	Grand Total	2,609,070.70

Bill No 006

Table 4.21: Summary of cost estimates for a typical, attached toilet building, toilet facilities and water supply for 500 users

S/N	ELEMENTS	COSTS
1.	Substructure	516,939.30
2.	Roof	343,521.00
3.	Walls	276,844.95
4.	Windows	83,677.95
5.	Doors	296,176.05
6.	Finishes	642,168.90
7.	Painting and Decoration	87,844.95
8.	Services	488,028.15
9.	Septic tank/soakaway	450,823.95
	Grand Total	3,186,025.20

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The objective of this project has been an exclusive study of water supply and sanitation to churches in Akure metropolis. The evaluation water supply and sanitation systems carried out was based on the criteria for acceptability and adequacy which revealed that the existing sanitation systems, in some of the churches were not appropriate. The existing pit latrines, in most churches were found not acceptable, while the water closet facility was not adequate for most churches.

The capacities of the existing systems in most churches were not adequate to serve the existing population which resulted in overloading of the systems and general poor sanitation practices in some areas affected. There was also poor distribution of sanitation facilities across the churches; from thirty people per facility to fifty people and above per facility.

The systems designed, based on the evaluation criteria built from this study, are water storage tank to take care of the water requirements in the churches, septic tanks and soakaway pits to accommodate the waste generated from the building it serves. The systems were both acceptable and adequate for different population levels presented.

6.2 Recommendations

Based on the results of this study, the following recommendations were made:

1. Where shallow wells are to be used as source of water supply, the distance between source of water and the septic tank should not be less 10m apart to avoid pollution through underground movement.

2. It is recommended that the storage tank designed for the different population levels should be strictly adhered to, as this will enhance consistent availability of water.
3. The recommended design for the septic and soakaway pit should be applied during the construction stage, mainly to avoid overloading of facilities.
4. The data on wells and boreholes in the study area should be consulted where shallow or deep well is required to serve as a guide in choosing the type of water source to be used.

REFERENCE

- Barry, R.** (1988) Construction of Building, Billing and Sons Ltd. Worcester, Britain Pg.1 – 6, 10 – 22.
- Blackett, I. C.** (1994), Low – Cost Urban Sanitation in Lesotho. UNDP – World Bank water and sanitation programme, Washington D.C. USA.
- Blankenbaker, E. Keith** (1987) Plumbing Good Heart – Willcox Company, INC. USA Pg 50-52
- Cainrncross, S. and Feachem, R. G.** (1983). Environmental Health Engineering in the Tropics: An Introductory text. John Wiley and Sons Ltd., Chichester, England.
- Callender, John Hancock** (1974). Time – Sawyer Standards for Architectural Design Data, USA.pg.878 – 880, 906 – 913.
- Chatterjee, A. K.** (2005). "Water Supply, Waste Disposal and Environmental Engineering" 7th Edition, 1-4, 378-381.
- Edwards, P.** (19920, Re – Use of Human Waste in Aquaculture: a Technical Review: UNDP – World water and sanitation programme. Washington D.C. USA.
- Escrutt, L. B.** (1972) ARCHITECTS' DATA, Blackwell Science Ltd. United Kingdom. Pp 182 – 185.
- Feachem, R., McGraw, M., and Mara, D.,** (1978). Water Waste and Health in Hot Climates. John Wiley and Sons Ltd. Chichester, England.

- Harris, Cyril, M.** (1990). Handbook of Utilities and services for Building, McGraw Hill Company. United States of America. Chapter 2 - 5
- Howard, S. P. Donald, R. R.** (1979) "Sewage Disposal and Air Pollution Engineering" Pp 465 – 481.
- Krison, N.** (1981), "Criteria for Evaluating Excreta Disposal Techniques" Sanitation in Developing Countries. John Wiley and Sons Ltd, Chichester, England. Pp43 – 48
- Max, P. and Charlotte, A.** (1996) "Wells and Septic Systems". Tab Book Ltd., 2nd Edition Pp 3-10, 95-119, 171-185.
- Merritt, F. S. and Maxkurtz, P. E.** (1986). Civil Engineering Reference Guide. McGraw – Hill Book Company, New York.
- Morgan, P.** (1991). Rural Water in Hot Climates. Macmillan Education Ltd. London. Pp 17-24.
- Pacey, A (Edit)** (1981). Sanitation in Developing Countries. John Wiley and Sons Ltd. Chichester, England.
- Roger, T. Walker, O.** (1978). Water Treatment Distribution, Prentice – Hall London. Pp. 7.
- Twort, A. O.** (1985). Water Supply, Edward Arnold Ltd. Great Britain, 1963, Pp. 115-120.

Unran, G. O. (1981). "Water Seal Pit Latrine" Sanitation in developing countries. John Wiley and Sons Ltd. Chichester, England. Pp. 104 – 106.

Watsan (2009), Data on Wells and Boreholes within Akure Study, Ondo state UNICEF ASSISTED Water and Sanitation (Project).

Watson (2002), Profile of Akure Metropolis.

Watson (1990) "Guidelines for Construction, Use and Maintenance of Ventilated Improved Pit (VIP) Latrine" Water and Sanitation (Watson) Section UNICEF – NIGERIA. Pp. 13 – 15.

WHO (1992), Drinking Sanitation: A Way of Health, World Health Organization, Geneva.

WHO (1992), International Standards for Drinking Water, World Health Organization, Geneva

Witlod, R. Chongrak, P. and Michael, M. (1982) "Appropriate Technology for Water Supply and Sanitation" Issues, International Drinking Water Supply and Sanitation Decade. Pp. 7 – 71.

Wright, A. M., Onusu, S. E. and Handa, V. K. (1981). "Availability of Latrines in a Developing Country", John Wiley and Sons Ltd., Chichester, England.

http://practicalaction.org/practicalanswers/product_info.php

[http://www.explainthatstuff.com/water pollution](http://www.explainthatstuff.com/water%20pollution)

APPENDICES

APPENDIX 1
DATA ON SAMPLED CHURCHES

S/N	NAME OF CHURCH	LOCATION	POPULATION
1.	Mount Carmel Glorious Ministry	Aduralere, Ijoka	70
2.	Victory church International	Aduralere, Ijoka	100
3.	All Christian Fellowship ministry	Ijoka road	85
4.	All christian Fellowship Ministry	Ijoka road	55
5.	All Christian Fellowship Ministry	Ala Quarters	250
6.	Reality Church of God	Oluwatuyi	120
7.	C.A.C Revival Centre	Oluwatuyi	1000
8.	C.A.C Ile-IyanuOluwa	Ijoka	2000
9.	Living Faith Winner Chapel	Oba-Ile	105
10.	Living Faith(HQ)	Ondo road	3000
11.	All christian Fellowship Ministry	Odopoljoka	55
12.	Amazing Lord Sanctuary	Igoba,Ado road	60
13.	Gospel Faith Mission	Aratosin,Oke-aroTitun	120
14.	Jerusalem Pentecostal Church	Aratosin,Oke-aroTitun	100
15.	Christ Disciple Church	Aratosin, Oke-aroTitun	80
16.	Christ Light Mission Church	Aratosin, Oke-aroTitun	100
17.	Gospel Faith Mission, Onapata	Aratosin,Oke – aroTitun	50
18.	Gospel Faith Mission, Tutugbua	Danjuma,offOnd o road	150
19.	Gospel Faith Mission, Ajebamidele	Isinkan	300
20.	Gospel Faith Mission, Ajipowo	Ajipowo, off ondo road	150
21.	Gospel Faith Mission, Barrack	Ondo road	50
22.	The Apostolic Church, Oke-Ayo	Shagari area	40
23.	Deeper Life Bible Church	Opp. Mobile Alagbaka	200
24.	Deeper Life Bible Church	Housing Estate	120
25.	Deeper Life Bible Church	Fastuase Layout	40
26.	Deeper Life Bible Church	Federal college of Agriculture	40
27.	The Word Bible Church	Ilesa road	150
28.	Christ Apostolic Church, Canaan Land	Lafe road	200
29.	Complete Bible Church	Off Ondo road	200
30.	AGAPE Christian Assembly	Off Ondo road	250
31.	Deeper Life Bible Church	Oba-Ile	130

32.	Christ Apostolic Church (Good news).	AjeboroAgagu Road.	1000
33.	Complete Christian Bible Church.	AjeboroAgagu Road.	250
34.	Redeemed Christian Church of God (Good Tiding Parish)	Oke-Ogba.	40
35.	C. A. C. (Okelpadepo)	Oke-Ogba.	1500
36.	C. A. C. (Canaan Land)	Lafe Inn.	250
37.	El.Shaddai (Mountain of Power and Miracle Church)	Opp C. A. C. United High School. Off Awule Rd	500
38.	The New Light Ministries	No 62, Awule Rd.	100
39.	C. A. C. (Ogba Ife Ti Oluwa)	AwuleRd.	100
40.	D. L. B. C. (Awule District)	SolegbadeStrt	200
41.	Christ Ministry of Grace International	SolegbadeStrt	500
42.	The Church of Jesus Christ of Latter Day Saint	OkutaElerinla	750
43.	C. A. C. (Bethel District).	Leo Hospital Rd, Oba Adesida Layout.	500
44.	The Renewed Christian assembly (Revival Center)	39 Leo Hospital Rd.	100
45.	Christ Word Mission and Ministry.	GbitecoStrt, Leo Rd.	150

46.	C. A. C. (OkeOluwadamilare).	50, MeseStrt, AyedunQutr	100
47.	Church of God	AyedunQutr.	100
48.	Four Square Gospel Church	AyedunQutr.	100
49.	Mountain of Fire and Miracle Ministries.	AjisoStrt, AyedunQutr.	50
50.	R. C. C. G. (Alpha & Omega Parish).	TuyiStrt, Ayedun.	100
51.	The Garden of Jesus Christ.	27, Tuyi Strt, Ayedun	100
52.	The Holy Community Church New World.	15, TuyiStrt, Ayedun.	50
53.	R. C. C. G. (Victory Parish).	Custom, Ondo Rd.	1000
54.	Jesus Shining Ministries.	GbemigunStrt, Fanibi.	500
55.	D. L. B. C. (FanibiDistrt).	GbemigunStrt, Fanibi.	500
56.	Kingdom of Jehovah Witness	Fanibi.	50
57.	The Beloved Church of God	Fanibi.	50
58.	R. C. C. G. (Redeemer Assembly).	Agunloye.	30
59.	The Eternal Sacred Order of Cherubim & Seraphim Church.	Fanibi.	100
60.	Celestial Church of Christ.	Agunloye.	750
61.	Mary Queen Nigeria Catholic.	Tutubgua,	50

		Danjuma.	
62.	Assemblies of God Church	Tutugbua.	50
63.	C. A. C. (OkeAgbra Adura).	AdelabuStrt, Danjuma.	50
64.	Soteria City Bible Ministries World Wide.	Adelabustrt, Danjuma.	150
65.	C. A. C. (OkeImole Miracle Center	Power Line, Danjuma.	50
66.	Christ Covenant Apostolic Church.	Eyin-Apata.	40
67.	Christ Fire Soul Winnings Evangelical Ministries.	Eyin-Apata.	80
68.	The Power of Holy Ghost Bible Church.	God's Glory Nur. & Pry. Schl Area, Eyin-Apata.	100
69.	Tender Mercies of God Tabernacle.	Falomo Layout, off Danjuma (OriApata).	50
70.	Christ Life Mission Outreach International.	Falomo Layout, off Danjuma (OriApata).	200
71.	C. A. C. OkeAjasegun.	Falomo Layout, off Danjuma (OriApata).	50
72.	The Fruit of Faith Ministries (Wonder Land).	Falomo Layout, off Danjuma (OriApata).	500

73.	Glory of God Gospel Church International.	Adegoleri Layout, Off Danjuma.	40
74.	R. C. C. G. Wind of Change Parish.	Adegoleri Layout, Off Danjuma.	50
75.	Salem Gospel Mission International.	TOFAS Sec. Schl Area.	100
76.	D. L. B. C. (IsikanDstrt)	ST John & Mary Hospital Area.	150
77.	R. C. C. G. (Jesus Resurrection Power Parish).	Aratunsin Layout, Oke-AroTitun.	40
78.	Salem Baptist Church.	Aratunsin Layout, Oke-AroTitun.	80
79.	Jerusalem Pentecostal Church.	Aratunsin Layout, Oke-AroTitun.	80
80.	The Gospel Faith Mission International.	Aratunsin Layout, Oke-AroTitun.	150
81.	D. L. B. C. (AratunsinDstrt).	Oke-Ado, Aratunsin.	100
82.	Jesus The Solution Evangelical Ministry.	Aratunsin Layout, Oke-AroTitun.	40
83.	Celestial Church of God.	Aratunsin Layout, Oke-AroTitun.	150
84.	D. L. B. C. (OoyeDstrt)	Eyin-Apata	50
85.	The New Salvation Church of Christ.	Olugunloye off Danjuma Rd.	150

86.	Divine Oasis Love Ministries.	24, Danjuma Rd.	50
87.	R. C. C. G. (River of Joy Parish).	3, AdinlewaStrt.	40
88.	Agape Christian Assembly (Oyemekun Branch).	53, AdinlewaStrt.	250
89.	D. L. B. C. (GbogiDstrt).	Gbogi.	80
90.	Heavenly Bound Citizen Minitries.	AdejolerinStrt.	40
91.	R. C. C. G.(Christ Chapel Parish).	AdejolerinStrt.	30
92.	C. A. C.(Solid Rock Assembly).	AdojolerinStrt.	100
93.	R.C. C. G. (The Crown of His Goodness Parish).	Agunloye	50
94.	Assemblies of God.	Gaga, Akure.	150
95.	D. L. B. C. (ArakaleDstrt).	Off Odi-Olowo Rd.	80
96.	Garden of Prayer Ministries.	Oke- OdoAratunsinQutr	80
97.	The Apostolic Church.	AratunsinQutrs.	60
98.	C. A. C. (OkeAgbaraOluwa).	No. 22A Oke- OdoQutrs	40
99.	End Time Holy Ghost Evangelical Ministries	AratunsinQutrs.	60
100	Dominion Tower (A. K. A. KING PALACE).	Ondo Bye, Opp ST Louis GrammerSchl.	40
101	Horeb crusaders ministries	Danjuma street	300
102	Light apostolic church	No 3 danjuma street	300
103	Cherubim And Seraphim Movt church	Danjuma street	200
104	Redeem Christian church of God(Anointing sanctuary)	Danjuma street	50

105	Power tabernacle gospel church	No 41,Oba-adebobajo street,OkeArotutun	40
106	Christ revelation covenant church	No 20,jeje street	80
107	Christ dominion church Int.	Jeje street	50
108	C .A .C OkeItusile	Jeje street	30
109	New born Jerusalem church	Jeje street	60
110	Redeem Christian church of God(Hope of glory sanctuary)	Arisoyin street, Oke-Arotuntun	50
111	Chapel of salvation ministries	Arisoyin street, Oke-Arotuntun	40
112	Kingdom hall of Jehovah witness	Arisoyin street, Oke-Arotuntun	30
113	Redeem Christian church of God(Heaven and Earth parish)	Arisoyin street, Oke-Arotuntun	40
114	The apostolic church	Oke- Aro assembly	60
115	Redeem Christian church of God(grace temple)	Bolajoko street	150
116	Spiritual church of God	Bolajoko street	40
117	Redeem Christian church of God(Divine assurance parish)	Moferere streetOke-Aro	50
118	Christ of Nazareth bible church	Oshinle street	40
119	Assembly of GodChurch (Victory Parish)	Oshinle quarters	200
120	C.A.C End Time	SolagbadeOshinle quarters	40
121	Apostle Gospel Ministry International.	SolagbadeOshinle quarters	30
122	Emmanuel Anglican Church	Oshinle	250
123	C.A.C.RevivalCenter	Off Ijoka Rd	1500
124	Apostolic FaithChurch.	Off Ijoka Rd	1000
125	R. C. C. G. (Gideon Parish)	Off St Micheal High Schl	40
126	CharityChurch of God	Power Line, Ijoka.	80
127	C. A. C. (Oke-AyobamiAduralere)	Power Line Ijoka	100
128	R. C. C. G. (The Lord's Assembly)	Power Line Ijoka.	250
129	The LivingWordMissionaryBaptistChurch	Power Line Ijoka	250
130	C. A. C. (Oke-OlorunKibati).	Power Line Ijoka.	100
131	New Testament Life Mission Inc.	Power Line Ijoka	40
132	D. L. B. C. (Ijoka English)	Power Line Ijoka	100
133	The Gospel Faith Mission (Odopo	Ijoka	150

	Assembly).		
134	C. A. C. (CannanLand) No. 1	Ijoka	150
135	R. C. C. G. (Brook of Cherith Parish)	Idi-AgbaTuntun	50
136	St. Mary The Virgin Anglican Church.	Alagbaka	200
137	R. C. C. G. (Beautifull Gate Cathedral)	Alagbaka	300
138	C. A. C. (Ona-Iye)	Alagbaka.	50
139	Reconcillation House.	Ijapo.	80
140.	CelestialChurch of Christ (Osofa Parish).	Owo Ilesha Express way	80
141.	GraceMissionaryBaptistChurch.	Ilesha Express way.	80
142.	R. C. C. G. (God's Power Assembly)	Ilesha Express Way.	30
143.	Assembly of God Church.	Beside C. A. C. United. Awule.	80
144.	CelestialChurch Of Christ	Agagu Rd.	30
145.	C. A. C. (Garden Of Peace).	Agagu Rd.	50
146.	Living Faith Winner's Chapel.	Ondo Rd.	1000
147.	The Apostolic Church.	Ondo Rd.	40
148.	C. A. C. (Leselese).	Ondo Rd.	80
149.	All Christian Fellowship Ministry.	Champion Junction, Oyemekun Rd.	120
150.	All Christian Fellowship Ministry.	Oba-Ile Rd.	50

APPENDIX 2

QUESTIONNAIRE



This questionnaire was part of ongoing research work titled:

“EVALUATION OF THE WATER SUPPLY AND SANITATION TO WATER SUPPLY TO CHURCHES IN ONDO STATE. (CHURCHES INN AKURE SOUTH AS CASE STUDY)”

This work is for a Master in Engineering Degree (M.Eng Degree) in the department of Civil Engineering at the Federal University of Technology, Akure.

Please you are requested to complete this questionnaire giving information to the best of knowledge. Every information given shall be for the purposes of the research work only and treated confidentially.

Thanks.

Yours faithfully

SMART OLUBAYODE

- (1) What is your Educational status? (a) educated (b) Not educated
- (2) sex of respondent (a) Male (b) Female
- (3) What is the name of the street where your worship center is located?
- (4) Is your site on lease or permanently acquired? (a) On lease (b) permanently acquired
- (5) What is the approximate size of the land? (a) Half plot (b) One plot (c) Two plots (d) Three plots (e) Four plots

- (6) What is the population of worshippers in your worship center? 9a) 50 – 100 (b) 101 – 200 (c) 201 – 300 (d) 301 – 400 (d) above 400
- (7) What is the average peak population of worshippers during worship service? (a) 100 (b) 200 (c) 300 (d) 400 (e) above 400
- (8) What is the average peak population of men during worship service? (a) 50 (b) 100 (c) 200 (d) 300 (e) above 300
- (9) What is the average peak population of female during worship services? (a) 50 (b) 200 (c) 200 (d) 300 (e) above 300

Section b

Water supply

10. Are there facilities for water supply in your place of worship?
(a) yes (b) No
11. If yes, what is the source your water supply? (a) well (b) borehole (c) pipe borne (d) tanker supply
12. Is the water supply adequate during the peak worship services? (a) yes (b) no
13. What is the distance between the toilet worship center and the source of water? (a) within the building (b) about 5 meters apart (c) about 10 meters apart (d) about 20 meters apart
14. Want can you say about the attitude of the people in your worship center towards the use of water provider? (a) satisfactory (b) not satisfactory
15. What type maintenance do you practice in the place of worship? (a) routine maintenance (b) preventive maintenance (c) corrective maintenance (d) none

16. Do you have adequate flow of water in the water pipes? (a) yes (b) no

SECTION C

17. Do you have toilet in your place of worship? (a) yes (b) no
18. If yes, what type of toilet facility do you have? (a) pit latrine (b) water closet (c) open field (d) mobile toilet
19. Is the toilet facilities in your place of worship adequate or not? (a) adequate (b) not adequate
20. do you have separate toilet for male and female (a) yes (b) no
21. What type of anal cleansing do you use in your place of worship? (a) maize cobs (b) toilet paper (c) water (d) any paper
22. What is the distance between the location of your worship building and your toilet? (a) within the building (b) about 5 meters apart (c) about 10 meters apart (d) about 20 meters apart
23. what type of toilet location will you prefer from question above (a) within the building (b) 5 meter apart (c) 10 meter apart (d) 20 meter apart (e) over 20 apart
24. What is the distance between the location of the septic tank/soakaway pit and the source of water? (a) about 5 meters (b) about 10 meters (c) about 20 meters (d) over 20 meters
25. Is the septic tank/soakaway pit in your place of worship of adequate size? (a) yes (b) no

APPENDIX 3

01: Detail of Bill of Engineering Measurement and Evaluation for Detached Toilet Facility for 100 users

	SOIL/WATER LAYOUT				
	<i>Substructures</i>				
	<i>New Work</i>				
	GROUND WORK				
	<i>Information</i>				
	The Contractor is to referred to the various Architectural and Structural drawings in relation to this section of the work for the nature and detailed content of the work to be executed.				
	All Provisional				
	EXCAVATION AND EARTHWORK				
	<i>Site preparation</i>				
A	Clear site to remove shrubs, undergrowth and small trees to include their disposal off-site.	39	m ²	100.00	3,900.00
B	<i>Excavation</i> Topsoil average 150mm deep	39	m ²	150.00	5,850.00
C	Trenches width not exceeding 0.30m maximum depth not exceeding 1.00m from excavated ground level	24	m ³	550.00	13,200.00
D	Excavating working space and filling in with selected material arising from excavations; disposing of surplus excavated material by removing from site around trenches to receive foundations; not exceeding 2.00 m deep	21	m ²	550.00	11,550.00
E	<i>Earth Work Support</i> maximum depth not exceeding 2.00m; distance between opposing faces 2.00 - 4.00m; in trenches	83	m ²	450.00	37,350.00
F	<i>Disposal</i> depositing on site in temporary spoil heaps located at Contractor's discretion	6	m ³	250.00	1,500.00
G	<i>Filling</i> Filling to excavation average thickness not exceeding 0.25m; materials arising from the excavations	10	m ³	250.00	2,500.00
H	Filling to excavations sand to be obtained off site average thickness not exceeding 0.25m	5	m ³	950.00	4,750.00
I	Hardcore filling to make up levels; deposited in layers 200mm maximum thickness; average thickness exceeding 0.25m	10	m ²	1,150.00	11,500.00
To Collection					92,100.00

A	<u>Surface treatment</u> Level and compact bottom of excavation to receive concrete	32	m ²	40.00	1,280.00
B	Prepare and apply one coat of "Dieldrex" or other similar equal and approved anti-termite treatment solution on faces of excavation	115	m ²	65.00	7,475.00
IN - SITU CONCRETE/ LARGE PRECAST CONCRETE					
6	E10: MIXING/CASTING/CURING/IN-SITU CONCRETE				
6	<u>Plain in-situ concrete blinding: mix 1:12, all in aggregate</u>				
C	Foundation trench; poured on or against earth or unblinded hardcore	8	m ³	20,500.00	164,000.00
D	Beds; laid on earth or hardcore 150-450mm thick	5	m ²	20,500.00	102,500.00
10	<u>Formwork generally</u>				
E	Edges or faces of bed; plain vertical not exceeding 250mm high vertical surfaces	23	m	300.00	6,900.00
F10 BRICKWORK AND BLOCKWORK					
<u>Hollow sandcrete blocks, 450 x 225, standard compressive strength, standard finish; in cement and sand mortar (1:4); stretcher bond; filled with weak concrete (1:10)</u>					
F	Walls; 225mm thick	31	m ²	2,500.00	77,500.00
P.C. SUMS/PROVISIONAL SUMS/DAYWORKS					
A54: PROVISIONAL WORK					
Include the following Provisional Sums:-					
For undefined Work					
G	ps Additional works to substructure		Sum		12,500.00
To Collection					372,155.00
Substructure Collection					
Page 1					92,100.00
Page 2					372,155.00
Total Substructure To Summary					464,255.00

Roof					
New Work					
CLADDING/COVERING					
H31: METAL PROFILED/FLAT SHEET CLADDING/COVERING/SIDING					
16	<i>Cladding: metal colour coated one side aluminium profiled step tiles sheeting. 0.70 gauge metal: standard colour: 150 end laps, secured with rivets at average 450 centres and sealed with mastic tape as manufactured by Tower Aluminium</i>				
A	Coverings; fixing to timber joists at 900 general spacing with galvanised mild steel drive screws; drilling holes pitch 15 degrees	54	m2	2,700.00	145,800.00
B	Hips girth 250	7	m	1,300.00	9,100.00
STRUCTURAL/CARCASSING METAL/TIMBER					
G20: CARPENTRY/TIMBER FRAMING/FIRST FIXING					
25	<i>Hardwood, sawn impregnated</i>				
C	Roof members; pitched 100 x 75; plate fixing with screws to masonry at both top and bottom	23	m	420.00	9,660.00
D	150 x 50; rafter fixing with screws to masonry at 900mm centres	67	m	400.00	26,800.00
E	75 x 100; purlins fixing with nail to timber members at 1200mm centres	64	m	420.00	26,880.00
F	50 x 50; noggins fixing with nail to timber members at 600mm centres	145	m	250.00	36,250.00
G	150 x 75; kingpost fixing with nail to timber members	15	m	450.00	6,750.00
H	50 x 75 ;Trusses fixing with nail to timber members	92	m	300.00	27,600.00
I	Fascia and barge boards width not exceeding 300; 300 x 25	28	m	550.00	15,400.00
K	150 x 75 ;tie beams fixing with nail to timber members	60	m	450.00	27,000.00
Total Roof To Summary					331,240.00

A	Walls New Works F10 BRICKWORK AND BLOCKWORK 11 LOADBEARING SUPERSTRUCTURE <i>Hollow sandcrete blocks, 450 x 225, standard compressive strength, standard finish: in cement and sand mortar (1:4), stretcher bond; flush smooth bonding as work proceeds</i>				
	Walls 225 thick	125	m ²	2,100.00	262,500.00
Total Walls To Summary					262,500.00

[illegible]

A	8	Doors				
		IN - SITU CONCRETE/ LARGE PRECAST CONCRETE				
		E10: MIXING/CASTING/CURING/IN-SITU CONCRETE				
		<i>Reinforced in-situ concrete; B.S.5328, designed mix C25, 20 aggregate, minimum cement content 330 kg/m³; vibrated</i>				
		Lintels	1	m3	22,500.00	22,500.00
		E20: FORMWORK FOR IN-SITU CONCRETE				
		<i>Formwork and basic finish</i>				
		Sides and soffit of lintel	5	m2	1,200.00	6,000.00
		E30: REINFORCEMENT FOR IN-SITU CONCRETE				
		<i>Reinforcement bars; B.S.4449, hot rolled deformed high yield steel</i>				
		8 - 16 diameter	0.04	ton	265,000.00	10,600.00
		L20: DOORS/SHUTTERS/HATCHES				
	20	<i>Flush doors</i>				
		Interior quality; well seasoned mahogany panelled door or other equal and approved, 45 hardwood, including frames, hinges and locks overall size 45 x 900 x 2100	2	nr	28,500.00	57,000.00
		Ditto 45 x 750 x 2100mm high	4	nr	13,500.00	54,000.00
	25	<i>Door frames and door lining sets in hardwood, wrot, selected for transparent finish</i>				
		Internal door frame sets; one coat external primer before delivery to site 900 x 2100 overall; 50 x 225 jambs and heads, rebates - 1, fixing to masonry with screws.	2	nr	9,500.00	19,000.00
		Internal door frame sets; one coat external primer before delivery to site 750 x 2100 overall; 50 x 225 jambs and heads, rebates - 1, fixing to masonry with screws.	4	nr	8,000.00	32,000.00
		BUILDING FABRIC SUNDRIES				
	26	P21: IRONMONGERY				
		<i>Ironmongery; union mortice with approved finish.</i>				
		To softwood frames and flush doors				
		Double cylinder mortice locks with set of lever handle furniture	6	nr	2,250.00	13,500.00
		rubber door stops	6	nr	800.00	4,800.00
		Total Doors				
		To Summary				219,400.00

		Wall Finishes				
		New Work				
		PLASTERWORK				
A	38	<i>Mortar, cement and sand (1:3); steel trowelled; internal</i>				
		12 work to walls on brickwork or blockwork base	184	m ²	450.00	82,800.00
B	38	<i>Mortar, cement and sand (1:3); steel trowelled; external</i>				
		13 work to walls on brickwork or blockwork base over 300 wide	66	m ²	450.00	29,700.00
		TILEWORK				
C	41	<i>Ceramic tiles, Pilkington's Suntan, semi-glazed; 2 joints, symmetrical layout; fixing with Bal Adhesives Ltd. CTF2, adhesive, grouting with matching coloured Bal-grout; internal to toilet and bath.</i>				
		200 x 200 x 6 units to walls on cement and sand base over 300 wide	129	m ²	2,950.00	380,550.00
		FLOOR FINISHINGS				
		BEDDING WORK				
D	39	<i>Mortar, cement and sand (1:4) Internally</i>				
		40 work to floors; on concrete base; level or to falls; Screeded; over 300 wide	33	m ²	650.00	21,450.00
		TILEWORK				
		M40: STONE/CONCRETE/QUARRY/CERAMIC TILING/MOSAIC				
E	41	<i>Vitrified floor tiles, B.S.6431, non-slippery fully vitrified, buff; 3 joints, symmetrical layout; bedding in 10 cement mortar (1:3); pointing in cement mortar (1:3).</i>				
		400 x 400 x 12 units to floors on cement and sand base; level to falls only not exceeding 15 degrees from horizontal; plain in toilets	6	m ²	2,800.00	16,800.00
		To Collection				531,300.00

Painting and Decoration					
NEW WORK					
M60: PAINTING/CLEAR FINISHING					
<i>All paint to be as manufactured by Berger, CAP Plc or others</i>					
A	44 <i>One mist coat and two full coats of emulsion paint.</i>				
	Cement rendered walls over 300 girth	55	m ²	550.00	30,250.00
NEW WORK EXTERNALLY					
B	44 <i>Two coats of Santex paint or other equal and approved weathershield paint on cement rendered surfaces</i>				
	Cement rendered walls over 300 girth	66	m ²	550.00	36,300.00
C	44 <i>Two coats of Santex paint or other equal and approved weathershield paint on asbestos ceiling board</i>				
	soffit of ceilings; generally	44	m ²	450.00	19,800.00
Total Painting and Decoration To Summary					86,350.00

SERVICES					
Supply and fix Twyford or other equal and approved sanitary fittings					
A	5- trap low level W.C suite complete	4	nr	13,500.00	54,000.00
B	550 x450mm white glazed wash hand basin complete	6	nr	5,500.00	33,000.00
C	urinal basin	2	nr	3,500.00	7,000.00
P.C. SUMS/PROVISIONAL SUMS/DAYWORKS					
PC	<u>A51: NOMINATED SUBCONTRACTORS INCLUDE THE FOLLOWING P.C. SUMS FOR WORK EXECUTED COMPLETE:-</u>				
D	Mechanical services installation		Sum		150,000.00
E	Electrical installation		Sum		100,000.00
<u>A54: PROVISIONAL WORK</u>					
Include the following Provisional Sums:-					
For undefined Work					
F	Builder's work in connection with services		Sum		25,000.00
SERVICES					
To Summary					369,000.00

		SEPTIC TANK/SOAKAWAY				
		All Provisional				
		EXCAVATION AND EARTHWORK				
		<i>Site preparation</i>				
A		Topsoli average 150mm deep	12	m ²	150.00	1,800.00
		<i>Trenches width not exceeding 0.30m maximum depth not exceeding 1.00m from excavated ground level</i>				
B			20	m ³	550.00	11,000.00
		<i>Disposal</i>				
		depositing on site in temporary spoil heaps located at Contractor's discretion	2	m ³	250.00	500.00
		F10 BRICKWORK AND BLOCKWORK				
		<i>Hollow sandcrete blocks, 450 x 225, standard compressive strength, standard finish, in cement and sand mortar (1:4); stretcher bond</i>				
D		Walls; 225mm thick	32	m ²	2,500.00	80,000.00
		PLASTERWORK				
		<i>38 Mortar, cement and sand (1:3); steel trowelled; internal</i>				
E		12 work to walls on brickwork or blockwork base	24	m ²	450.00	10,800.00
		BEDDING WORK				
		<i>39 Mortar, cement and sand (1:4) Internally</i>				
F		40 work to floors; on concrete base; level or to falls; Screeded; over 300 wide	10	m ²	650.00	6,500.00
G		broken blocks to soak away waste water from septic tank	2	m ²	1,150.00	2,300.00
		CONCRETE WORK				
		IN - SITU CONCRETE/ LARGE PRECAST CONCRETE				
		8 E10: MIXING/CASTING/CURING/IN-SITU CONCRETE				
		<i>Reinforced in-situ concrete: B.S.5328, designed mix C25, 20 aggregate, minimum cement content 330 kg/m3; vibrated</i>				
H		septic tank/soakaway slab	2	m ³	22,500.00	45,000.00
		To collection				157,900.00

SEPTIC TANK/SOAKAWAY cont'd					
E20: FORMWORK FOR IN-SITU CONCRETE					
Formwork and basic finish					
A	Sides and soffit of septic tank/soakaway pit	15	m2	1,200.00	18,000.00
E30: REINFORCEMENT FOR IN-SITU CONCRETE					
Reinforcement bars: B.S.4449, hot rolled deformed high					
B	8 - 16 diameter	0.21	ton	265,000.00	55,650.00
Manhole/inspection chamber					
C	manhole/inspection chamber size 550 x 550 x 450mm	6	nr	6,500.00	39,000.00
To collection					112,650.00
Page 11					157,900.00
Page 12					112,650.00
SEPTIC TANK/SOAKAWAY PIT					270,550.00
To Summary					

SUMMARY				
	Substructure			464,255.00
	Roof			331,240.00
	Walls			262,500.00
	Windows			69,025.00
	Doors			219,400.00
	Finishes			566,500.00
	Painting and decoration			86,350.00
	Services			369,000.00
	Septic tank/soakaway pit			270,550.00
TOTAL SOIL/WATER LAYOUT TO GENERAL SUMMARY				2,638,820.00

SOIL/WATER LAYOUT					
<i>Substructures</i>					
<i>New Work</i>					
GROUND WORK					
<i>Information</i>					
The Contractor is to referred to the various Architectural and Structural drawings in relation to this section of the work for the nature and detailed content of the work to be executed.					
All Provisional					
EXCAVATION AND EARTHWORK					
<i>Site preparation</i>					
A	Clear site to remove shrubs, undergrowth and small trees to include their disposal off-site.	43	m ²	100.00	4,300.00
<i>Excavation</i>					
B	Topsoil average 150mm deep	43	m ²	150.00	6,450.00
C	Trenches width not exceeding 0.30m maximum depth not exceeding 1.00m from excavated ground level	26	m ³	550.00	14,300.00
D	Excavating working space and filling in with selected material arising from excavations; disposing of surplus excavated material by removing from site around trenches to receive foundations; not exceeding 2.00 m deep	22	m ²	550.00	12,100.00
E	<i>Earth Work Support</i> maximum depth not exceeding 2.00m; distance between opposing faces 2.00 - 4.00m; in trenches	91	m ²	450.00	40,950.00
F	<i>Disposal</i> depositing on site in temporary spoil heaps located at Contractor's discretion	7	m ³	250.00	1,750.00
G	<i>Filling</i> Filling to excavation average thickness not exceeding 0.25m; materials arising from the excavations	11	m ³	250.00	2,750.00
H	Filling to excavations sand to be obtained off site average thickness not exceeding 0.25m	6	m ³	950.00	5,700.00
I	Hardcore filling to make up levels; deposited in layers 200mm maximum thickness; average thickness exceeding 0.25m	11	m ³	1,150.00	12,650.00
To Collection					100,950.00

A	Surface treatment Level and compact bottom of excavation to receive concrete	35	m ²	40.00	1,400.00
B	Prepare and apply one coat of "Dieldrex" or other similar equal and approved anti-termite treatment solution on faces of excavation	126	m ²	65.00	8,190.00
IN - SITU CONCRETE/ LARGE PRECAST CONCRETE					
6 E10: MIXING/CASTING/CURING/IN-SITU CONCRETE					
6 Plain in-situ concrete blinding; mix 1:12, all in aggregate					
C	Foundation trench; poured on or against earth or unblinded hardcore	8	m ³	20,500.00	164,000.00
D	Beds; laid on earth or hardcore 150-450mm thick	6	m ³	20,500.00	123,000.00
10 Formwork generally:					
E	Edges or faces of bed; plain vertical not exceeding 250mm high vertical surfaces	25	m	300.00	7,500.00
F10 BRICKWORK AND BLOCKWORK					
<i>Hollow sandcrete blocks, 450 x 225, standard compressive strength, standard finish: in cement and sand mortar (1:4); stretcher bond; filled with weak concrete (1:10)</i>					
F	Walls; 225mm thick	34	m ²	2,500.00	85,000.00
P.C. SUMS/PROVISIONAL SUMS/DAYWORKS					
A54: PROVISIONAL WORK					
Include the following Provisional Sums:-					
For undefined Work					
G	PS Additional works to substructure		Sum		15,000.00
To Collection					404,090.00
Substructure Collection					
Page 1					100,950.00
Page 2					404,090.00
Total Substructure To Summary					505,040.00

Roof					
New Work					
CLADDING/COVERING					
H31: METAL PROFILED/FLAT SHEET					
CLADDING/COVERING/SIDING					
16	<i>Cladding: metal colour coated one side aluminium profiled step tiles sheeting, 0.70 gauge metal; standard colour: 150 end laps, secured with rivets at average 450 centres and sealed with mastic tape as manufactured by Tower. Aluminium</i>				
A	Coverings; fixing to timber joists at 900 general spacing with galvanised mild steel drive screws; drilling holes pitch 15 degrees	59	m2	2,700.00	159,300.00
B	Hips girth 250	7	m	1,300.00	9,100.00
STRUCTURAL/CARCASSING METAL/TIMBER					
G20: CARPENTRY/TIMBER FRAMING/FIRST FIXING					
25	<i>Hardwood, sawn impregnated</i>				
C	Roof members; pitched 100 x 75; plate fixing with screws to masonry at both top and bottom	25	m	420.00	10,500.00
D	150 x 50; rafter fixing with screws to masonry at 900mm centres	75	m	400.00	30,000.00
E	75 x 100; purlins fixing with nail to timber members at 1200mm centres	70	m	420.00	29,400.00
F	50 x 50; noggins fixing with nail to timber members at 600mm centres	158	m	250.00	39,500.00
G	150 x 75; kingpost fixing with nail to timber members	17	m	450.00	7,650.00
H	50 x 75; Trusses fixing with nail to timber members	103	m	300.00	30,900.00
I	Fascia and barge boards width not exceeding 300; 300 x 25	29	m	550.00	15,950.00
K	150 x 75 ;tie beams fixing with nail to timber members	68	m	450.00	30,600.00
Total Roof					
To Summary					362,900.00

A	Walls				
	New Works				
	F10 BRICKWORK AND BLOCKWORK				
11	LOADBEARING SUPERSTRUCTURE				
	<i>Hollow sandcrete blocks, 450 x 225, standard compressive strength, standard finish, in cement and sand mortar (1:4); stretcher bond; flush smooth bonding as work proceeds</i>				
	Walls				
	225 thick	135	m ²	2,100.00	283,500.00
Total Walls To Summary					283,500.00

Doors					
IN - SITU CONCRETE/ LARGE PRECAST CONCRETE					
B	E10: MIXING/CASTING/CURING/IN-SITU CONCRETE				
	<i>Reinforced in-situ concrete: B.S.5328, designed mix C25.20 aggregate, minimum cement content 330 kg/m3; vibrated</i>				
A	Lintels	1	m3	22,500.00	22,500.00
E20: FORMWORK FOR IN-SITU CONCRETE					
	<i>Formwork and basic finish</i>				
B	Sides and soffit of lintel	6	m2	1,200.00	7,200.00
E30: REINFORCEMENT FOR IN-SITU CONCRETE					
	<i>Reinforcement bars: B.S.4449, hot rolled deformed high yield steel</i>				
C	8 - 16 diameter	0.06	ton	265,000.00	15,900.00
L20: DOORS/SHUTTERS/HATCHES					
20	Flush doors				
	Interior quality; well seasoned mahogany panelled door or other equal and approved, 45 hardwood, including frames, hinges and locks overall size 45 x 900 x 2100	2	nr	28,500.00	57,000.00
E	Ditto 45 x 750 x 2100mm high	6	nr	13,500.00	81,000.00
25	Door frames and door lining sets in hardwood, wrot, selected for transparent finish				
F	Internal door frame sets; one coat external primer before delivery to site 900 x 2100 overall; 50 x 225 jambs and heads, rebates - 1, fixing to masonry with screws.	2	nr	9,500.00	19,000.00
G	Internal door frame sets; one coat external primer before delivery to site 750 x 2100 overall; 50 x 225 jambs and heads, rebates - 1, fixing to masonry with screws.	6	nr	8,000.00	48,000.00
BUILDING FABRIC SUNDRIES					
26	P21: IRONMONGERY				
	<i>Ironmongery: union mortice with approved finish.</i>				
	To softwood frames and flush doors				
H	Double cylinder mortice locks with set of lever handle furniture	8	nr	2,250.00	18,000.00
I	rubber door stops	8	nr	800.00	6,400.00
Total Doors					
To Summary					275,000.00

		Wall Finishes				
		New Work				
		PLASTERWORK				
	38	<i>Mortar, cement and sand (1:3); steel trowelled; internal</i>				
A		12 work to walls on brickwork or blockwork base	202	m ²	450.00	90,900.00
	38	<i>Mortar, cement and sand (1:3); steel trowelled; external</i>				
B		13 work to walls on brickwork or blockwork base over 300 wide	69	m ²	450.00	31,050.00
		TILEWORK				
	41	<i>Ceramic tiles, Pilkington's Suntan, semi-glazed; 2 joints, symmetrical layout; fixing with Bal Adhesives Ltd. CTF2 adhesive, grouting with matching coloured Bal-grout; internal to toilet and bath.</i>				
C		200 x 200 x 6 units to walls on cement and sand base over 300 wide	141	m ²	2,950.00	415,950.00
		FLOOR FINISHINGS				
		BEDDING WORK				
	39	<i>Mortar, cement and sand (1:4) Internally</i>				
D		40 work to floors; on concrete base; level or to falls; Screeded; over 300 wide	37	m ²	650.00	24,050.00
		TILEWORK				
		M40: STONE/CONCRETE/QUARRY/CERAMIC TILING/MOSAIC				
	41	<i>Vitrified floor tiles, B.S.6431, non-slippery fully vitrified, buff; 3 joints, symmetrical layout; bedding in 10 cement mortar (1:3); pointing in cement mortar (1:3).</i>				
E		400 x 400 x 12 units to floors on cement and sand base; level to falls only not exceeding 15 degrees from horizontal; plain in toilets	8	m ²	2,800.00	22,400.00
		To Collection				584,350.00

Painting and Decoration

NEW WORK

M60: PAINTING/CLEAR FINISHING

All paint to be as manufactured by Berger, CAP Plc or others

44 One mist coat and two full coats of emulsion paint.

Cement rendered walls
over 300 girth

61

 π^2

550.00

33,550.00

NEW WORK EXTERNALLY

44 Two coats of Santex paint or other equal and approved
weathershield paint on cement rendered surfaces

Cement rendered walls
over 300 girth

69

 m^4

550.00

37,950.00

44 Two coats of Santex paint or other equal and approved
weathershield paint on asbestos ceiling board

soffit of ceilings; generally

48

m2

450.00

21,600.00

Total Painting and Decoration

[To Summary](#)

93,100.00

	SEPTIC TANK/SOAKAWAY				
	All Provisional				
	EXCAVATION AND EARTHWORK				
	<i>Site preparation</i>				
A	Topsoil average 150mm deep	20	m ²	150.00	3,000.00
B	Trenches width not exceeding 0.30m maximum depth not exceeding 1.00m from excavated ground level	36	m ³	550.00	19,800.00
	<i>Disposal</i>				
C	depositing on site in temporary spoil heaps located at Contractor's discretion	3	m ³	250.00	750.00
	F10 BRICKWORK AND BLOCKWORK				
	<i>Hollow sandcrete blocks, 450 x 225, standard compressive strength, standard finish: in cement and sand mortar (1:4); stretcher bond</i>				
D	Walls; 225mm thick	41	m ²	2,500.00	102,500.00
	PLASTERWORK				
	<i>38 Mortar, cement and sand (1:3); steel trowelled; internal</i>				
E	12 work to walls on brickwork or blockwork base	33	m ²	450.00	14,850.00
	BEDDING WORK				
	<i>39 Mortar, cement and sand (1:4) internally</i>				
F	40 work to floors; on concrete base; level or to falls; Screeded; over 300 wide	18	m ²	650.00	11,700.00
G	broken blocks to soak away waste water from septic tank	2	m ²	1,150.00	2,300.00
	CONCRETE WORK				
	IN - SITU CONCRETE/ LARGE PRECAST CONCRETE				
	8 E10: MIXING/CASTING/CURING/IN-SITU CONCRETE				
	<i>Reinforced in-situ concrete; B.S.5328, designed mix C25, 20 aggregate, minimum cement content 330 kg/m³; vibrated</i>				
H	septic tank/soakaway slab	3	m ³	22,500.00	67,500.00
	To collection				222,400.00

A	SEPTIC TANK/SOAKAWAY cont'd					
	E20: FORMWORK FOR IN-SITU CONCRETE					
	<i>Formwork and basic finish</i>					
	Sides and soffit of septic tank/soakaway pit	24	m2	1,200.00	28,800.00	
B	E30: REINFORCEMENT FOR IN-SITU CONCRETE					
	<i>Reinforcement bars: B.S.4449, hot rolled deformed high</i>					
	B - 16 diameter	0.36	ton	265,000.00	95,400.00	
C	Manhole/inspection chamber					
	manhole/inspection chamber size 550 x 550 x 450mm	8	nr	6,500.00	52,000.00	
To collection					176,200.00	
Page 11					222,400.00	
Page 12					176,200.00	
SEPTIC TANK/SOAKAWAY PIT To Summary					398,600.00	

SUMMARY			
Substructure			505,040.00
Roof			362,900.00
Walls			283,500.00
Windows			85,500.00
Doors			275,000.00
Finishes			622,750.00
Painting and decoration			93,100.00
Services			490,500.00
Septic tank/soakaway pit			398,600.00
TOTAL SOIL/WATER LAYOUT TO GENERAL SUMMARY			3,116,890.00

	SOIL/WATER LAYOUT				
	<i>Substructures</i>				
	<i>New Work</i>				
	GROUND WORK				
	<i>Information</i>				
	The Contractor is to referred to the various Architectural and Structural drawings in relation to this section of the work for the nature and detailed content of the work to be executed.				
	All Provisional				
	EXCAVATION AND EARTHWORK				
	<i>Site preparation</i>				
A	Clear site to remove shrubs, undergrowth and small trees to include their disposal off-site.	71	m ²	100.00	7,100.00
B	<i>Excavation</i>				
B	Topsoil average 150mm deep	71	m ²	150.00	10,650.00
C	Trenches width not exceeding 0.30m maximum depth not exceeding 1.00m from excavated ground level	41	m ³	550.00	22,550.00
D	Excavating working space and filling in with selected material arising from excavations; disposing of surplus excavated material by removing from site around trenches to receive foundations; not exceeding 2.00 m deep	30	m ²	550.00	16,500.00
E	<i>Earth Work Support</i> maximum depth not exceeding 2.00m; distance between opposing faces 2.00 - 4.00m; in trenches	143	m ²	450.00	64,350.00
F	<i>Disposal</i> depositing on site in temporary spoil heaps located at Contractor's discretion	11	m ³	250.00	2,750.00
G	<i>Filling</i> Filling to excavation average thickness not exceeding 0.25m; materials arising from the excavations	16	m ³	250.00	4,000.00
H	Filling to excavations sand to be obtained off site average thickness not exceeding 0.25m	10	m ³	950.00	9,500.00
I	Hardcore filling to make up levels; deposited in layers 200mm maximum thickness; average thickness exceeding 0.25m	19	m ³	1,150.00	21,850.00
To Collection					159,250.00

A		Surface treatment Level and compact bottom of excavation to receive concrete	54	m ²	40.00	2,160.00
B		Prepare and apply one coat of "Dieldrex" or other similar equal and approved anti-termite treatment solution on faces of excavation	197	m ²	65.00	12,805.00
IN - SITU CONCRETE/ LARGE PRECAST CONCRETE						
6		E10: MIXING/CASTING/CURING/IN-SITU CONCRETE				
6		<i>Plain in-situ concrete blinding; mix 1:12, all in aggregate</i>				
C		Foundation trench; poured on or against earth or unblinded hardcore	13	m ³	20,500.00	266,500.00
D		Beds; laid on earth or hardcore 150-450mm thick	10	m ³	20,500.00	205,000.00
10		<i>Formwork generally</i>				
E		Edges or faces of bed; plain vertical not exceeding 250mm high vertical surfaces	33	m	300.00	9,900.00
F10 BRICKWORK AND BLOCKWORK						
		<i>Hollow sandcrete blocks, 450 x 225, standard compressive strength, standard finish: in cement and sand mortar (1:4); stretcher bond; filled with weak concrete (1:10)</i>				
F		Walls; 225mm thick	54	m ²	2,500.00	135,000.00
P.C. SUMS/PROVISIONAL SUMS/DAYWORKS						
A54: PROVISIONAL WORK						
Include the following Provisional Sums:-						
For undefined Work						
G	PS	Additional works to substructure		Sum		25,000.00
To Collection						656,365.00
Substructure Collection						
		Page 1				159,250.00
		Page 2				656,365.00
Total Substructure						
To Summary						815,615.00

Roof					
New Work					
CLADDING/COVERING					
H31: METAL PROFILED/FLAT SHEET					
CLADDING/COVERING/SIDING					
16	<i>Cladding: metal colour coated one side aluminium profiled step tiles sheeting, 0.70 gauge metal; standard colour: 150 end laps, secured with rivets at average 450 centres and sealed with mastic tape as manufactured by Tower Aluminum</i>				
A	Coverings; fixing to timber joists at 900 general spacing with galvanised mild steel drive screws; drilling holes pitch 15 degrees	94	m2	2,700.00	253,800.00
B	Hips girth 250	12	m	1,300.00	15,600.00
STRUCTURAL/CARCASSING METAL/TIMBER					
G20: CARPENTRY/TIMBER FRAMING/FIRST FIXING					
25	<i>Hardwood, sawn impregnated</i>				
C	Roof members; pitched 100 x 75; plate fixing with screws to masonry at both top and bottom	33	m	420.00	13,860.00
D	150 x 50; rafter fixing with screws to masonry at 900mm centres	117	m	400.00	46,800.00
E	75 x 100; purlins fixing with nail to timber members at 1200mm centres	112	m	420.00	47,040.00
F	50 x 50; noggins fixing with nail to timber members at 600mm centres	147	m	250.00	36,750.00
G	150 x 75; kingpost fixing with nail to timber members	26	m	450.00	11,700.00
H	50 x 75; Trusses fixing with nail to timber members	161	m	300.00	48,300.00
I	Fascia and barge boards width not exceeding 300; 300 x 25	38	m	550.00	20,900.00
K	150 x 75 ;tie beams fixing with nail to timber members	105	m	450.00	47,250.00
Total Roof					542,000.00
To Summary					

A	Walls				
	New Works				
	F10 BRICKWORK AND BLOCKWORK				
11	LOADBEARING SUPERSTRUCTURE				
	<i>Hollow sandcrete blocks, 450 x 225, standard compressive strength, standard finish: in cement and sand mortar (1:4); stretcher bond: flush smooth bonding as work proceeds</i>				
	Walls				
	225 thick	208	m ²	2,100.00	436,800.00
Total Walls					
To Summary					436,800.00

	Windows				
	New Works				
	CONCRETE WORK				
	IN - SITU CONCRETE/ LARGE PRECAST CONCRETE				
B	E10: MIXING/CASTING/CURING/IN-SITU CONCRETE				
	<i>Reinforced in-situ concrete: B.S.5328, designed mix C25, 20 aggregate, minimum cement content 330 kg/m3; vibrated</i>				
A	Lintels	1	m3	22,500.00	22,500.00
	E20: FORMWORK FOR IN-SITU CONCRETE				
	<i>Formwork and basic finish</i>				
B	Sides and soffit of lintel	11	m2	1,200.00	13,200.00
	E30: REINFORCEMENT FOR IN-SITU CONCRETE				
	<i>Reinforcement bars: B.S.4449, hot rolled deformed high</i>				
C	8 - 16 diameter	0.1	ton	265,000.00	26,500.00
	P.C. SUMS/PROVISIONAL SUMS/DAYWORKS				
PC	A51: NOMINATED SUBCONTRACTORS INCLUDE THE FOLLOWING P.C. SUMS FOR WORK EXECUTED COMPLETE:-				
D	Aluminum Glass Windows (Approximate area of 7m ²)				66,500.00
E	Add for main contractor's profit	5	%		3,325.00
WINDOWS					
To Summary					132,025.00

Doors					
IN - SITU CONCRETE/ LARGE PRECAST CONCRETE					
8	E10: MIXING/CASTING/CURING/IN-SITU CONCRETE				
	<i>Reinforced in-situ concrete: B.S.5328, designed mix C25, 20 aggregate, minimum cement content 330 kg/m³; vibrated</i>				
A	Lintels	1	m ³	22,500.00	22,500.00
E20: FORMWORK FOR IN-SITU CONCRETE					
	<i>Formwork and basic finish</i>				
B	Sides and soffit of lintel	12	m ²	1,200.00	14,400.00
E30: REINFORCEMENT FOR IN-SITU CONCRETE					
	<i>Reinforcement bars: B.S.4449, hot rolled deformed high yield steel</i>				
C	8 - 16 diameter	0.11	ton	265,000.00	29,150.00
L20: DOORS/SHUTTERS/HATCHES					
20	Flush doors				
	Interior quality; well seasoned mahogany panelled door or other equal and approved, 45 hardwood, including frames, hinges and locks overall size 45 x 900 x 2100				
D		2	nr	28,500.00	57,000.00
E	Ditto 45 x 750 x 2100mm high	13	nr	13,500.00	175,500.00
25	Door frames and door lining sets in hardwood, wrot, selected for transparent finish				
F	Internal door frame sets; one coat external primer before delivery to site 900 x 2100 overall; 50 x 225 jambs and heads, rebates - 1, fixing to masonry with screws.	2	nr	9,500.00	19,000.00
G	Internal door frame sets; one coat external primer before delivery to site 750 x 2100 overall; 50 x 225 jambs and heads, rebates - 1, fixing to masonry with screws.	13	nr	8,000.00	104,000.00
BUILDING FABRIC SUNDRIES					
26	P21: IRONMONGERY				
	<i>Ironmongery: union mortice with approved finish.</i>				
	To softwood frames and flush doors				
H	Double cylinder mortice locks with set of lever handle furniture	15	nr	2,250.00	33,750.00
J	rubber door stops	15	nr	800.00	12,000.00
Total Doors					
To Summary					467,300.00

		Wall Finishes				
		New Work				
		PLASTERWORK				
	38	<i>Mortar, cement and sand (1:3); steel trowelled; internal</i>				
A		12 work to walls on brickwork or blockwork base	325	m ²	450.00	146,250.00
	38	<i>Mortar, cement and sand (1:3); steel trowelled; external</i>				
B		13 work to walls on brickwork or blockwork base over 300 wide	92	m ²	450.00	41,400.00
		TILEWORK				
	41	<i>Ceramic tiles, Pilkington's Suntan, semi-glazed, 2 joints, symmetrical layout; fixing with Bal Adhesives Ltd. CTF2 adhesive, grouting with matching coloured Bal-grout; internal to toilet and bath.</i>				
C		200 x 200 x 6 units to walls on cement and sand base over 300 wide	228	m ²	2,950.00	672,600.00
		FLOOR FINISHINGS				
		BEDDING WORK				
	39	<i>Mortar, cement and sand (1:4) Internally</i>				
D		40 work to floors; on concrete base; level or to falls; Screeded; over 300 wide	63	m ²	650.00	40,950.00
		TILEWORK				
		M40: STONE/CONCRETE/QUARRY/CERAMIC TILING/MOSAIC				
	41	<i>Vitrified floor tiles, B.S.6431, non-slippery fully vitrified, buff; 3 joints, symmetrical layout; bedding in 10 cement mortar (1:3); pointing in cement mortar (1:3)</i>				
E		400 x 400 x 12 units to floors on cement and sand base; level to falls only not exceeding 15 degrees from horizontal; plain in toilets	18	m2	2,800.00	50,400.00
		To Collection				951,600.00

	SERVICES				
	<u>Supply and fix Twyford or other equal and approved sanitary fittings</u>				
A	S- trap low level W.C suite complete	13	nr	13,500.00	175,500.00
B	550 x450mm white glazed wash hand basin complete	14	nr	5,500.00	77,000.00
C	urinal basin	5	nr	3,500.00	17,500.00
	P.C. SUMS/PROVISIONAL SUMS/DAYWORKS				
PC	<u>A51: NOMINATED SUBCONTRACTORS INCLUDE THE FOLLOWING P.C. SUMS FOR WORK EXECUTED COMPLETE:-</u>				
D	Mechanical services installation		Sum		300,000.00
E	Electrical installation		Sum		150,000.00
	<u>A54: PROVISIONAL WORK</u>				
	Include the following Provisional Sums:-				
	For undefined Work				
F	Builder's work in connection with services		Sum		50,000.00
	SERVICES				
	To Summary				770,000.00

SEPTIC TANK/SOAKAWAY					
All Provisional					
EXCAVATION AND EARTHWORK					
A	<i>Site preparation</i>				
	Topsil average 150mm deep	27	m ²	150.00	4,050.00
B	Trenches width not exceeding 0.30m maximum depth not exceeding 1.00m from excavated ground level	47	m ³	550.00	25,850.00
	<i>Disposal</i>				
C	depositing on site in temporary spoil heaps located at Contractor's discretion	4	m ³	250.00	1,000.00
	F10 BRICKWORK AND BLOCKWORK				
D	<i>Hollow sandcrete blocks 450 x 225 standard compressive strength standard finish in cement and sand mortar (1:4) stretcher bond</i>				
	Walls; 225mm thick	46	m ²	2,500.00	115,000.00
PLASTERWORK					
E	38 <i>Mortar, cement and sand (1:3); steel trowelled; internal</i>				
	12 work to walls on brickwork or blockwork base	38	m ²	450.00	17,100.00
BEDDING WORK					
F	39 <i>Mortar, cement and sand (1:4) Internally</i>				
	40 work to floors; on concrete base; level or to falls; Screeded; over 300 wide	25	m ²	650.00	16,250.00
G	broken blocks to soak away waste water from septic tank	2	m ²	1,150.00	2,300.00
	CONCRETE WORK				
IN - SITU CONCRETE/ LARGE PRECAST CONCRETE					
H	8 E10: MIXING/CASTING/CURING/IN-SITU CONCRETE				
	<i>Reinforced in-situ concrete; B.S.5328, designed mix C25, 20 aggregate, minimum cement content 330 kg/m³; vibrated</i>				
H	septic tank/soakaway slab	4	m ³	22,500.00	90,000.00
To collection					271,550.00

SEPTIC TANK/SOAKAWAY cont'd					
E20: FORMWORK FOR IN-SITU CONCRETE					
<i>Formwork and basic finish</i>					
A	Sides and soffit of septic tank/soakaway pit	31	m2	1,200.00	37,200.00
E30: REINFORCEMENT FOR IN-SITU CONCRETE					
<i>Reinforcement bars: B.S.4449, hot rolled deformed high</i>					
B	8 - 16 diameter	0.47	ton	265,000.00	124,550.00
Manhole/inspection chamber					
C	manhole/inspection chamber size 550 x 550 x 450mm	10	nr	6,500.00	65,000.00
To collection					226,750.00
Page 11					271,550.00
Page 12					226,750.00
SEPTIC TANK/SOAKAWAY PIT					
To Summary					498,300.00

SUMMARY			
Substructure			815,615.00
Roof			542,000.00
Walls			436,800.00
Windows			132,025.00
Doors			467,300.00
Finishes			1,013,200.00
Painting and decoration			138,600.00
Services			770,000.00
Septic tank/soakaway pit			498,300.00
TOTAL SOIL/WATER LAYOUT TO GENERAL SUMMARY			4,813,840.00