DESIGN OF SURFACE DRAINAGE FOR MEDIUM FARM HOLDING

(CASE STUDY OF IDACHE FARM, ABUJA)

BY

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APPROVAL PAGE

The project is an original work of Pyels Emmanuel Danladi (PGD/Agric. Eng. /2004/188) under the supervision of Eng. Dr. Egharevba of agricultural Engineering Department, Federal University of Technology Minna.

This project has been prepared, in accordance with the standards, for the preparation of post-graduate Diploma in Agricultural Engineering. It is submitted in partial fulfillment of the requirement for the award of post-graduate Diploma certificate in agricultural engineering it hereby accepted and approved.

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Engr. Dr. Egharevba Date
Project Supervisor

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Head of Department

CERTIFICATION

This is to certify that this project titled "Design of surface drainage for Medium farm holding (Case study of Idache farm, Abuja)" was carried out by me (Pyels Emmanuel Danladi, PGD/AGRIC.ENG/2005/188) under the supervision of Engr. Dr. Egharevba of Agricultural Engineering Department, Federal University of Technology, Minna, Nigeria.

All authors whose works were used in this thesis have been duly acknowledged.

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Yusuf Olasunkanmi Sarafa	DATE

DEDICATION

This project work is dedicated to my wife and children and specially to Almighty God.

ACKNOWLEDGEMENT

This project and the entire course could not have been complete without the effort and contributions of the following persons.

I must first of all acknowledge the Almighty God for sustaining me all through the course. I would also want appreciate my abled supervisor Eng. Dr. Egharevba for his patience in going through the scripts one after the other. I will not forget to acknowledge the contributions and advices of Engr. Dr. Z. Osunde (Head of department) Engr. Dr. Alabadan the PG coordinator.

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CHAPTER ONE

1.0 INTRODUCTION

Agricultural drainage is the use of surface ditches, subsurface permeable pipes or both to remove standing or excess water from poorly drained lands. It can also be defined as the collection and disposal of excess water from agricultural lands or the lowing of ground water table below plants root zones.

Many soils in Nigeria and other regions of the world have poor natural drainage, and would remain water logged for several days without artificial drainage after rain. This prolonged wetness prevents timely fieldwork and causes stress to growing crops, because saturated soils do not provide sufficient aeration for crop root development. Some soils on the other hand, because of their sloppy topography, tend to speed up erosion as a result of an controlled surface run off, consequently removing the top soil which is basically needed by plants. Some areas in Nigeria would not reliably produce crop if artificial drainage system is not provided.

Soil water related problems have been a matter of great concern to governments, especially third world countries located within the tropics because of high rainfall. Controlled drainage has become recognized as an effective practice for preventing stagnant water or uncontrolled surface run off. This system generally helps in soil conservation, retention of soil fertility, improvement of field condition for timely tillage, planting, harvesting and other farm operations.

Water logging and uncontrolled surface runoff in agricultural lands are both phenomenon's that can lead to serious soil degradation. The provision of adequate drainage system in an agricultural land improves its productivity.

1.1 JUSTIFICATION

The need for an artificial drainage system in an agricultural land becomes necessary when the ground water table is high or when excess surface water cannot easily infiltrate down beyond the root zone of the soil, leading to prolong wetness of the soil. Most small-scale farmers, especially in developing countries have abandoned parts of their farmlands because of poor drainage, which usually is associated with poor yield. In view of the present government policy on agriculture, there is a need for agricultural engineers in Nigeria to take a critical look at the devastating effect of poor drainage agricultural lands with a view of finding a solution to it. This will bring about improved yield and thereby improving the standard of living of the local farmer.

1.2 AIMS AND OBJECTIVE

The farm under consideration (Idache farms) presently has no drainage system. This has made the flat and relatively low laying areas which is usually water logged from the months of July to early October not to be properly utilized as expected. It is, however, believed that if a properly designed drainage system is put in place, it will improve the soil condition and crop yield will increases.

This project will also help in controlling the hydrological effect of surface runoff downstream through the proper channeling of total water drainage into a

Well-defined outlet. Lack of proper drainage channels is one of the greatest factors responsible for poor agricultural production in developing countries. This project is therefore aimed at addressing such problems, by coming up with:-

(i) A well-designed drainage channel for the farm and

(ii) Recommending appropriate measures for sustainability of the drainage project

1.3 SCOPE

This project is to come out with a suitable drainage system for Idache farms in Kuje area council, FCT. This involves an investigation into the climate of the area like, rainfall, temperature, humidity and the topography of the land as well as the physical and chemical properties of the soil. Results from these investigations well help in estimating the highest average discharge that is expected to flow through the channel within the design period.

This project will be limited to surface drainage only and will cover an area of 67531.401m3, which is above 6.75ha.

CHAPT ER TWO

2.0 LITERATURE REVIEW

The main purpose of draining agricultural land is to remove excess water so as to improve the productivity of the land. Excess water either on the surface of the land as surface ponding or it may be deeper down the soil profile causing water logging of the root zone, farmers must make a significant financial investment when installing agricultural drainage system. They will make this investment for two reasons.

i. Agricultural drainage systems usually increase crop yield on poorly drained soils by providing a better environment for plant to grow, especially on wetlands.

ii. The system generally help to improved field condition for general farm operations .The two factors have improved agricultural production on nearly one-fifth (1/5) of U.S Soils. The most recent USDA comprehensive Survey of drained lands showed that in 1985, 30% of all agricultural lands in Upper Mid-west of U.S.A were artificially drained (Lowel and Gary, 2002).

2.1 CAUSES OF WATER LOGGING.

2.1.1 TOPOGRAPHY:

The shape and topography of a land can cause wet soil condition, especially around depressions where water tends to accumulate. Without an outlet, the water may drain away very slowly (Chleg and Dupriez, 1988). Observed that upstream section of a catchment area is always responsible for the water logging of the lower lands. This is because water either from natural rainfall or irrigation, flows from higher to lower course.

2.1.2 SOIL TEXTURE:

The sand, silt and clay composition of the soil mineral particles in a soil is called soil texture. For a loam soil texture, for example, the mineral content might consist of 40% clay, 30%slit and 30% sand. This can have a dramatic effect on how well the soil holds water and how easily water can move through the soil. Fine texture soil with high percentage of clay and particles generally hold water well, but drain poorly (Larry and Andrew, 1997).

2.1.3 SOIL STRUCTURE

According to (Chleg and Dupriez, 1988). Controlling excess water into an area as well as monitoring human activities and practices to improve soil strength and structural stability is a necessary step which must be attempted towards preventing problems associated with poor drainage. (Isrealsen and Hunsen, 1962), observed that in addition to eliminating or controlling excess water into an area. Improving natural drainage system and provision of man-made drainage facilities will be of importance in lowering the water table to mitigate drainage situations. Physical arrangement of soil mineral particles of soil is reefed to as soil structure. Granular structure helps promote the movement of water through a soil, but a structure that is massive (lacking any distinct arrangement of soil particles).

Usually reduces the movement of water (Larry and Andrew, 1997).

2.1.4 SOIL MOISTURE

The need for drainage may depend on the degree of moisture content in a soil (Faniran and Areola, 1978). They further stressed that, when the soil is totally devoid of water, all the pore spaces are filled with air and the soil is in a fully aerobic condition. However, when all the pores are filled with water, the soil is water logged, leading to anaerobic condition. They also stated that between these two extremes, various moisture to – air ratios are possible. It is worthy of note that one of the moisture to – air ratios identified was termed "imperfect" or poorly drained soil. This was explained as a situation in which there is a continuous fluctuation between aerobic and anaerobic conditions, which may be related to seasonal fluctuation in the level of the water table or to periodic inundation of the soil by floodwater. They equally stated that imperfectly drained soils might occur at receiving sites along hill slopes. However, for these types of soils to be use productively, drainage facilities must be installed at the sites considering also orientation and degree of slope of the land area.

In conjunction with the above, another drainage class identified by (Faniran and Areola, 1978) was termed "impeded or very poor drained soil". This was noted as a case where there is a definite obstacle to downward percolation of water so that the soil is always saturated. This was attributed to the presence of impermeable layers below the surface, which results in a high water table. They also said that these types of soil drainage may be found at the foot of hills or mountains or where a low laying area lies adjacent to a higher land that direct all its water towards the low area.

2.1.5 RAINFALL

Though the distribution of rain across the middle belt varies, Abuja receives an abundant supply of rain very year. This amount is enough to sustain high crop yield. However, excess rainfalls often produce excess soil water condition.

(Greenalnd and Lat, 1979) reported that poorly drained areas are always under utilized because of their unsuitability for use. However, they noted that, by following a conservation plan, these areas could be reclaimed and turned into useful areas for agricultural production or for further developmental projects. (Forth, 1978) suggested that, draining a land entails assessment of characteristics such as soil types and topography. (Forth, 1990) also stated that poorly drained areas hinder rapid development and effective utilization of the land.

Hudson (1985) in his own observation stated that land pattern, climate and runoff arising from the area can adequately be considered in planning for effective land drainage.

Hudson *et al.*)1979_ emphasized that, many benefits are attributed to drainage and these include improving soil aeration, increased microbial activities and reduced chances of soil erosion and gullying through improving infiltration capacity of soil.

Bancy (1995) reported that drainage problem is not limited only to low-lying or relatively flat lands, as even in steep slopes, absence of designed channels lead to severe land destruction by erosion, hence rapid development of gullies can be seen.

2.2 EFFECT OF WATER LOGGING AN ROOT DEVELOPMENT

2.2.1 Root Development

Proper drainage promotes better root growth and plants health than when soils have poor internal drainage, because saturated soils do not provide sufficient aeration for crop root development (lowell busman and gary sands 2002)

2.2.2 Root Function

Symptoms of damage of water logging such as retarded growth, chlorosis, abscission epinasty and development of advantageous roots are characteristic of change in hormonal balance. Example, increase in auxin in roots shoot may affect stem growth. It was also observed that increase in abscissic acid concentration in root shoot could contribute to stomatal closure (Wright and Hiran, 1972). It was also observed that increase in ethylene concentration in root shoot could be associated with signs of water logging damages.

2.2.3 Water Uptake and Nutrients

Soil saturation reduces the uptake of Many minerals from the soil like nitrogen, phosphate, potassium etc. The movement of these nutrients to shoots as well as the transportation of nutrients such as nitrogen out of older leaves can be reduced greatly, leading to damage to plants.

2.2.4 Nitrogen Loss in reply to: Soils

Nitrogen deficiency can cause yellowing of crop leaves. In anaerobic soil, it is normally thought that formation of nitrate is almost completely inhibited. In anaerobic soil, nitrate may be lost by dinitrification and by leaching, although leaching is not affected by oxygen supply.

2.3 HIERARCHY OF DRAINS:

A hierarchy of three orders of drains is available. In a typical agricultural drainage system, these comprise of the tertiary collectors, the secondary collectors and the natural water course (outlet).

2.3.1 Tertiary Collectors

This is made up of a network of field drains (open channels), which gathers the excess water from the area (field system) and discharges it into the primary drains.

2.3.2 Secondary Collectors

These receive water from the tertiary collectors and convey them safely to the outlet drains, which is usually a natural watercourse.

2.3.3 The Outlet Drains

This is the terminal point of the whole drainage system that receives all the water from the field and discharges it into a major natural system like a river, lake or the sea.

2.4 HYDROLOGY

Although agricultural drainage has benefited agricultural production in many regions and countries of the world, there are concerns about its potential environmental impact, there are concerns, however, about the potential negative impact of drainage on the hydrology of watersheds, the water quality of receiving water bodies and the amount of nearby wetlands, Drainage system are designed to alter field hydrology (water balance) by removing excess water from the water logged soils, there are concerns about the downstream hydrological effects caused by draining the excess water, (Busman and Sands, 2002) Anecdotal evidence, they said has indicated that streams and ditches have become flashier over time, spilling over thrie banks and causing localized crop damage. This problem can be solved or reduced through the provision of well-designed drainage system.

Surface drainage improvements are designed for two purpose: to minimize crop damage resulting from surface ponding an the soil surface following a rainfall event, and to control runoff without causing erosion.

2.5 TYPES OF DRAINAGE SYSTEM

2.5.1 DITCHES OR OPEN DRAINS

These vary in size and length and can be simply categorized as follows;

i. Shallow surface drains (up to 0.3m deep) formed by hand, shovel or spinner cuts, removing ponded water from shaollow depressions to larger.

ii. Drains or streams. They are suitable for draining large flat areas. They tends to be temporary in nature since they can be affected by animals, silt up quickly, over grown with less desirable species, wrecked by machines, weather and so on. They are very inconvenient for feel work or passenger vehicles as conservation equipment.

iii. Medium size drains. They measure between 0.3m to 1.0m. they are made by excavations or specific drainage equipment usually "V" shape with a flat bottom with enough slope (gradient) to ensure that the water drains quickly but not cause scouring of the drain walls or bottom. This is usually not a problem when drains are used on the flatter areas. The velocity of water flow should be slow on the sand loam soils and can be quicker on the clay and clay loam soils.

lays may have a slope or batter of 1:1, silt and clay loams 1:1 to 1:1.5 and :1.5 to 1:2, while looser sandier soils should be 1:2 to 1:3 and above.

ne size of drains depends on the amount of water to be removed or intercepted nd is available to calculate the required design parameters (Frank, 2002).

5.2 sub/surface drainage

ubsurface drainage is designed to remove excess water from soil quickly nough to minimize crop stress in most year. This is the laying of underground erforated pipes to convey excess water from the soil to nearby water course.

Agricultural engineering have developed depth and spacing guide lines for installing drainage pipes. Examples, recommendation for the many clay-loam soils prevalent in much of south Minesota call for placing pipes approximately three feet deep and 60 feet apart or four feet deep.

The objective of subsurface drainage is to drain excess water from the plant root zone of the soil profile by artificially lowing the water table level. subsurface drainage improvement is designed to control the water table level through a series of drainage pipes (or tubing) that are installed below the soil surface, usually just below the root zone.

Subsurface drainage improvement requires some minor maintenance of the outlet though which they empty. Subsurface drainage improvements generally are more expensive than surface drainage improvement.

Whether the drainage improvement is surface, subsurface or a combination of both, the objective usually is to remove excess water quickly and safety to reduce the potential for crop damage.

2.6 EFFECT OF DRAINAGE ON WATER QUICKLY.

Subsurface drainage (enhancing over land run off) tends to increase the lost of nutrients and sediment that occur with surface run off.

Subsurface drainage, however, can decrease surface run off, thereby reducing sediment cases by16 to 65 percent and phosphorous loses by up to 45 percent. (Busman and Garry, 2002).

The main water quality concerned about subsurface drainage is the increase lost of nitrates and other soluble constituent that can move through soil to drainage system and end up in nearby water. In addition, surface intakes, which are common across southern Minnessotan and Northern Iowa was observed by Busman and Garry, 2002 to provide a direct path way for sediment and other contaminants in surface run off to nearby surface water.

2.7 DRAINAGE AS EROSION CONTROL MEASURE

The main constraint of cultivation on sloping lands is water erosion leadings to soil degradation. According to some Scientists. Under ideal condition, it takes about 30 years to form a soil layer of 3.54cm (Thai et al, 1997). It is not easy to rehabilitate the lost soil, so sustainable soil management by soil erosion control is very important. Most soil erosion problems worldwide are being controlled through the construction of subsurface drainage system s. drainage control therefore plays a very vital role in agricultural production.

CHAPTER THREE

3. MATERIALS AND METHOD

The Project was; carried out in two phases namely;

1. Preliminary studies

2. Reconnaissance survey and data collection

3.1 Preliminary Studies.

The preliminary phase of this project is based on secondary source of data. It started with research into previous works done by other people on similar or the same projects. It also involved detail research into textbooks, journals, and newsletters, published by others researchers as well as publications from Internet. This aspect of work proceeded field investigation.

Another preliminary activity was getting the topographical map of the study area, which was obtained from the department of agricultural land resources, Federal ministry of Agriculture and Rural Development, Abuja.

3.2 Reconaisance Survey and Data Collection.

This involved short field trips to the project site for identification and pre-feasibility study of the area. The purpose of this visit was to carry out on the spot assessment of the problems on farm and the physical nature of the land.

It was found out that the reason for the water logging of the area in question was as a result of high water table. There was no natural drainage and no artificial drainage facility to drain the excess water.

3.2.1 LOCATION;

Abuja is located about 65km north of the confluence of the Niger and Benue rivers. It lies between longitude 6^0 and 7^o east and latitude 8^0 15 and 9^0 28 north. It is located within the tropical hinterland climatic region, characterized by double maximum rainfall (Ileoje, 1981).

3.2.2 TOPOGRAPHY:

The land is characterized by an adulating topography. This could be seen from the topographical map. The topographic map was drawn at a scale of 1:3.33, showing a contour interval of 0.5m. The highest point on the map is 105m and the lowest is 89.0m,. the detailed topographical map is attached at back cover.

3.2.3 CLIMATE

3.2.3.1 Rainfall:

Rainfall is a climate factor which causes most drainage problems in the tropics, especially when evapotraspiration (ET) is exceeded during long or short periods. Rainfall begins in April and terminates in October with its peak fall in September.

The average length of dry season is generally about four months. The period of adequate soil moisture availability to support rain fed agriculture is

Approximately estimated to be 200 days, this figure is based on the average cumulative period of the effective length of wet season (Okoye et al, 1986).

The average monthly rainfall for a period of Ten years for Abuja was obtained from the F.C.T agricultural Development project meteorological station. This would be used for the estimation of the average peak discharge expected at the project area within the design period. Table 1.1 refers.

TABLE 3.1 METROLOGICAL WEATHER DATA IN FCT – ABUJA FROM 1993 – 2005.

YEARS	RAINFALL IN (MM)	TEMPERATURE O°C		RELATIVE HUMIDITY IN %
		Max.	min.	
1993	1169.5	34	23	66
1994	1098.4	34	24	62
1995	1001.0	34	24	64
1996	1074.0	33	23	47
1997	1186.2	34	23	69
1998	1147.8	34	24	70
1999	1235.7	34	22	74
2000	1441.8	32	24	79
2001	185.8	33	21	78
2002	1132.1	33	23	70
2003	776.6	32	23	71
2004	830.2	34	24	77
2005	454.5	34	24	75

SOURCE: FCT – ADP PRS WEATHER DATA BANK (2006

3.2.3.3 Temperature

The month of February to many is usually the hottest periods in this latitude. The hightes temperature recorded within ten years was 34^{o}C (Table 1.1).

3.2.3.3 Humidity

Table 2 give the mean relative humidity in percentage for Abuja, which drops considerably to 47% in the dry season and at peak of the rainfall season, it rises to about 79%. This affects the moisture content of the soil and to a large extend determines the infiltration rate of the soil. (Table 1.1)

3.2.4 SOIL

3.2.4. Sampling Method

The word sampling in soil survey means the taking of a small specimen of soil to represent a body of soil for a particular experiment; hence the term representative soil sample is used. (Hudson, 1978). For better representation and high accuracy, sampling is done by digging test pits at uniform intervals of about 1.5m apart. A 2kg sample is taken with the aid of a auger from the test pit and properly sealed in a sampling bag to avoid lost of moisture and contamination. This sample is taken to the laboratory for analysis.

3.2.4.2 Determination of Particle Size

Sieve analysis was the method used for the determination of the particle size distribution of the soil sample. The moisture was taken and the soil sample air-dried. A nest of sieves were placed one upon the other and the soil sample passed through it. The sieve holes were 3.35mm, 2.0mm, .18mm, 850um, 600um, 425um, 212um, 150um,and 63um.This sieve nest is properly shaken and each sand particle was caught on the sieve through which it could not passed. The relative proportion of sand, silt and clay in the particle size analysis of the soil is used to determine the soil textural class.

3.2.4.3 Textural Determination

The type of weathering in humid tropic imposes certain special characteristics on soil texture. These characteristics which include a relatively high content of clay, low to very low content of silt and the presence of pseudo-sands often constitute a serious limitation to the use of the international and the USDA textural diagram {Okoye et al, 1986) observed that the mechanical analysis of tropical soils shows that, compared to soils of other climatic zones, tropical soils have a relatively high clay content and a low to very low silt content.

These are also characterized by the presence of fine elementary particles cemented mainly by oxide of iron. These characteristics are a direct result of the Type of intense chemical weathering of the parent material, which tends to leave only the very resistant residue. As a result of these high clay and low silt content, only a small part, about 10 of the international and USDA textural diagram can be used for tropical soils. Because of this limitation, FACAN proposed that a special equilateral triangle be used for the textural classification of the tropical soils. He suggested that textural classes be based on the relative importance of the following three fractions

A. Fine elements with diameter of 0-0.02mm(silt + clay in the international classification).

B. Fine sand with diameter of 0.02-0.2mm.

C. Coarse sand with diameter of 0.2-2.0mm.

on this basis he distinguished the following textural classes:

Heavy clay: more than 80% fine elements.

Clay: 60% - 80% fine elements,

Fine sandy clay: 40% - 60% fine elements, predominance of coarse sand

Coarse sandy clay: 40% - 60% fine elements, predominance sand

Fine sandy clay: 10% - 40% fine elements, predominance

Coarse clay sand: 10% - 40% fine elements, predominance of coarse sand

Fine sand: less than 10% fine elements, predominance of fine sand

Coarse sand: less than 10 fine elements predominance of coarse sand.

In effect he formulated five main divisions heavy clay, clay, sandy clay, clay sandy and sandy and subdivided the last three to fine and coarse fractions, thus bringing the total number to eight compared with the USDA diagram. There is no clear distinction between heavy clay and clays, fine sandy clays and sandy clay or fine sand and coarse sands.

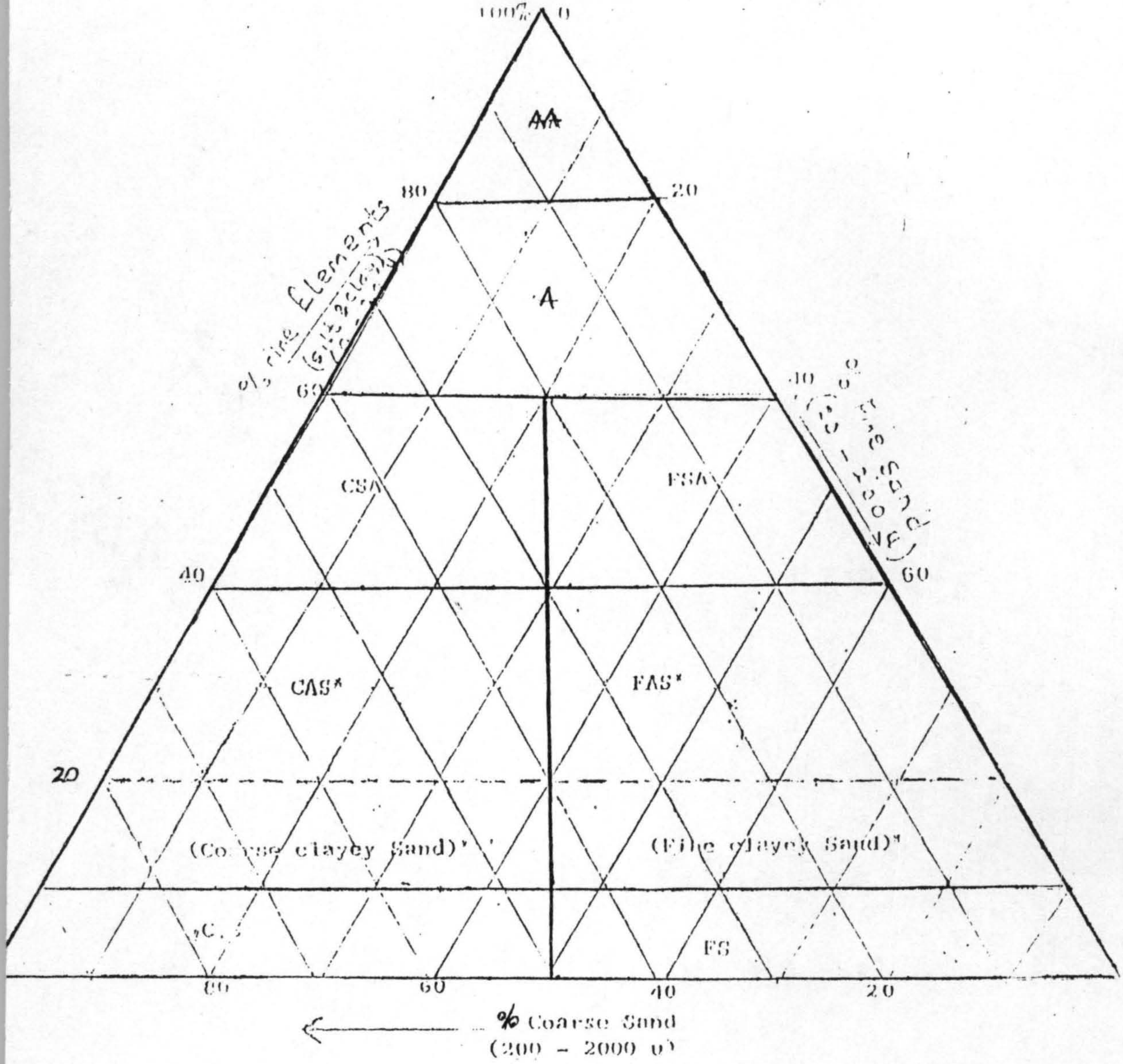

Fig. 3.1 Soil textural diagram suitable for humid tropics

Textural classes

AA - Heavy clay
A - Clay
CSA - Coarse Sandy clay
FSA - Fine Sandy clay
CAS - Coarse clayey Sand
FAS - Fine clayey Sand
C.S. - Coarse sand
F.S. - Fine Sand

In using the diagram, the points corresponding to the percentages of fine sand and fine elements present in the soil under consideration are located on the fine sand and fine elements lines respectively. Lines are then projected inward, parallel in the first case to the fine elements side of the triangle and in the second case parallel to the coarse sand side, the name of the compartment in which the two lines intersect is the class name of the soil in question.

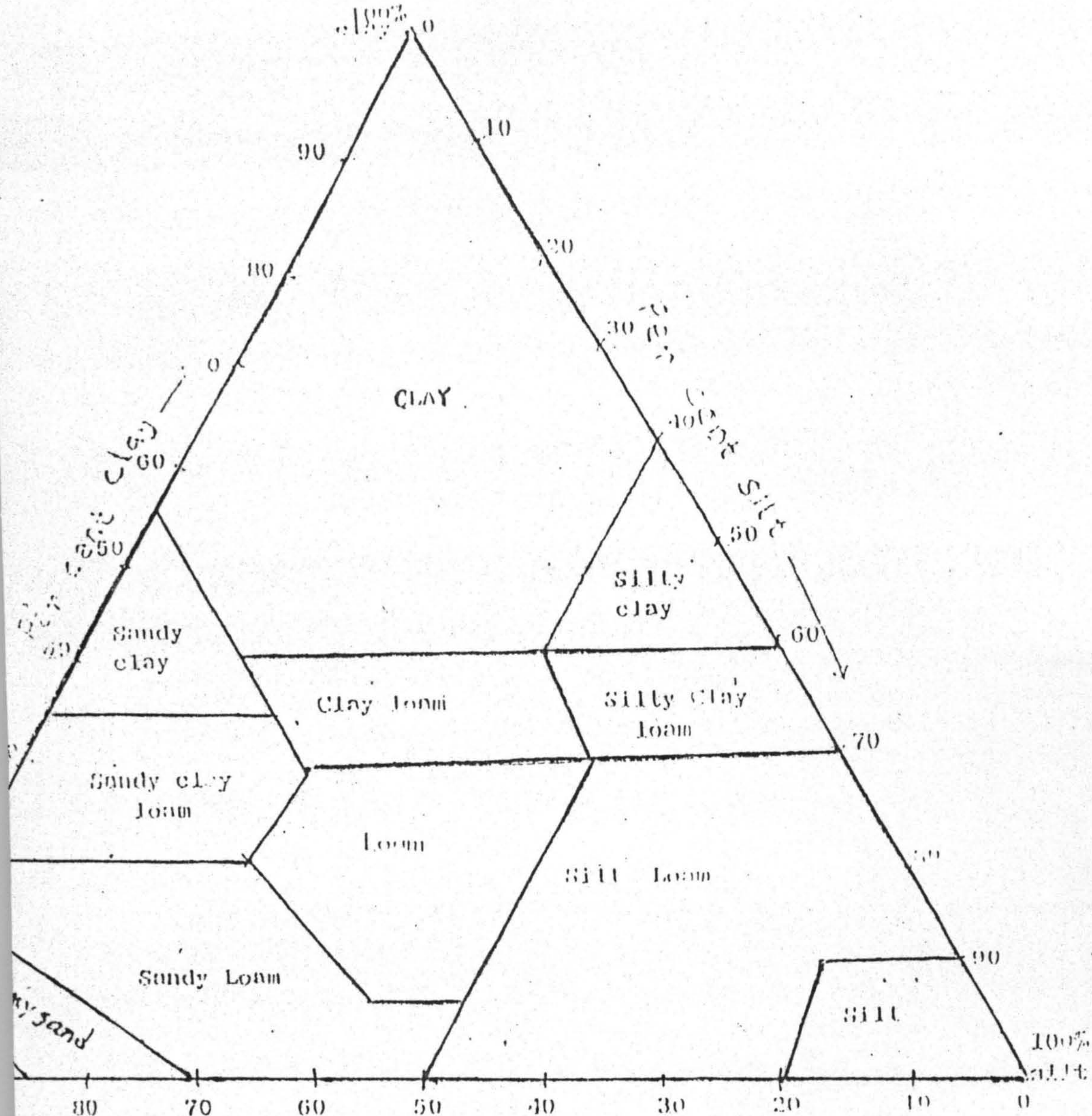

Fig. 3.2 Soil textural diagram (International)

In using the diagram, the points corresponding to silt and clay are located on the silt and clay lines respectively. Lines are then projected toward, parallel in the first case to the clay side of the triangle and in the second case parallel to the sand side.

3.2.4.4 Moisture Condition/Water Table

The soil was observed to be poorly drained especially at the surface horizon. Here the soil has a high moisture holding capacity.

The soil survey unit of the Federal Department of Land Resources observed that there was evidence of high water table. The water table was observed not to be below 50cm to 60cm.

CHAPTER FOUR

4.0 DESIGN ANALYSIS

4.0 DRAINAGE SYSTEM (LAYOUT)

The selection of drainage system for an area depends largely on the topography and the characteristics of the oil, the type of crop and the availability of an appreciate outlet.

A typical drainage system consists of field drains (tertiary collectors), which collect water from the land surface to the secondary drains, then to the main drainage outlet. These channels are laid in various patterns depending on the filed conditions

4.2 Total Land Area

The total area of the land to be drained could be calculated from the topographical map provided. The map is drawn using a scale of 1cm: 3.33cm.

Measurement on the map gives the following:

58cm by 105cm

i.e. Area = 58cm x 3.33cm by 105cm x 3.33m = 193. 14m x 349.65m. = 67531.401m^2 = 6.75ha.

4.2 Rainfalls

Rainfall record for a period of 10 years obtained from the F.C.T Agricultural Development Project Meteorological unit was adopted for use in this project.

The record shows that the highest rainfall was recorded in the year 2000, with an average of 1,441.3mm.

4.4 Slope Estimation(S)

This can also be calculated from the topographical map, as follows:

The highest point of the map = 105m

The lowest point on the map = 89m

Vertical height difference = 105m - 89m = 16.0m

The longest distance of flow from the most remote area on the farm to the outlet is measured to be = 95cm.

i.e. 95cm x 3.33m = 316.35m.

:. Slope (s) = $\frac{\text{vertical height}}{\text{Horizontal distance of flow}}$

= $\frac{16.0m}{316.35m}$ = 0.050

Slope (s) = 0.050

4.5 SOIL TEXTURE/MOISTURE CONTENT

From the soil analysis, the soil is clay loam silt with a high percentage of fine materials. It was also observed to have a high moisture holding capacity with a water table of not far below 50cm.

4.6 SIDE SLOPE (Z)

The side slope of an open drain depends primarily on the stability and structure of the soil. Side slopes are selected based on soil characteristics; because the steeper the drainage channels the more likely it is to cave inside.

Recommended side slopes for different types of soils are shown in the table below:

TABLE 4:1 SIDE SLOPE RATIOS FOR OPEN DRAINAGE FOR DIFFERENT SOILS.

Soil	Shallow channels up to 1.2m	deep channels 1. 2m and above
Peat and muck	Vertical	¼ :1
Stiff (heavy) clay	½:1	1:1
Clay or silt loam	1:1	1 1/2 :1
Sandy loam	1 ½ :1	2:1
Loose sandy	2:1	3:1

SOURCE: ETCHEVERRY, (1931)

4.7 ROUGHNESS COEFFICIENT(n)

The value of the roughness coefficient for a soil in drainage design is based on soil type and farming activities carried out on the land. For the purpose of this design, a roughness coefficient of 0.60 will be used based on the soil type earlier described. Values of recommended roughness coefficients for different soils are shown in the table below.

TABLE 4.2: TYPICAL VALUES OF ROUGHNESS COEFFICIENT (n) FOR VARIOUS SURFACES

Topography and vegetation	Soil Texture			
	Open	sandy clay loam	clay and silt loam	tight clay
Woodland				
Flat 0-5% slope	0.10		0.30	0.40
Rolling 5-10% slope	0.25		0.35	0.50
Hilly 10-30% slope	0.30		0.50	0.60
Pasture				
Flat	0.10		0.30	0.40
Rolling	0.16		0.36	0.55
Hilly	0.22		0.42	0.60
Cultivated				
Flat	0.30		0.50	0.60
Rolling	0.40		0.60	0.70
Hilly	0.52		0.72	0.82

Source: (Schwab, *et al.*, 1931)

4.8 Channel Design

The trapezoidal shape will be used here because it is more stable and more economical to construct.

A good drainage channel is expected to be;

(i) Non silting and non scouring

(ii) It is expected to have adequate capacity to carry the design flow

(iii) It should have enough depth for effective drainage

(iv) It should have a stable side slope to avoid caving in.

Fig 4.1 Cross section of trapezoidal drainage channel

4.9 runoff estimation

To estimate the total runoff (Q), the rational fomular method will be used.

This is given as

$$Q = \frac{CIA}{360} \quad (m^3/s)$$

Where,

Q = rate runoff in m^3/s

I = rainfall intensity in mm/hr

A = Total catchment area in hectares

C = dimensional constant

While the value of 360, arises from the metric units of Q (that is the rate of discharge) in the formula stated above.

i.e Q m^3/s = C x I mm/hr x A ha.

$= C \times I\ (mm/3600s) \times A\ (10^4 m^2)$

$= C \times I\ (10^{-3} m/3600s) \times A\ (10^4 m^2)$

$$Q = \frac{CIA}{360} \quad (m^3/s)$$

To solves this equation for total runoff, it is necessary to know the three factors on the right side of the equation

Area (A) has been computed from the map

C is a constant from table based on soil type.

The rainfall intensity (I) has to be calculated from the rainfall records collected. From the F.C.T Agricultural Development Project Meteorological unit and the Nnamdi Azikwe International Airport Abuja, rainfall intensity was not available neither was the rainfall duration recorded. This was found out to be due to lack of appropriate equipments. However, the formula;

$$I = \frac{K_n}{(t_c + a)^b}$$

will be used in this case.

Where I = rainfall intensity

t_c = time of concentration (gathering time)

$K_n = A + B \log_{10} N$

Where N = Design period for the drainage which is 10 years

(A,B,a,b) = station constants for the area.

TABLE 4.3 GATHERING TIME FOR SMALL CATCHMENTS

Max. Length of run	Average gradient of catchments (%)					
	0.05	0.1	0.5	1.0	2.0	5.0
100	12	9	5	4	3	2
200	20	16	8	7	5	4
500	44	34	17	14	10	8
1000	75	58	30	24	18	13
2000	130	100	50	40	31	22
3000	175	134	67	55	42	30
4000	216	165	92	70	54	38
5000	250	195	95	82	65	45

Source: Nigeria High way design manual (1975).

Since station contents for Abuja are not available, stations constants for Ikeja with a maximum average rainfall of 1,588.90 will be used,

Since it is similar to Jos which is close to Abuja.

Station constants for Ikeja are (NHDN, 1975).

A = 3.280

B = 2.340

a = 0.600

b = 0.9520

Time of Concentration (Tc)

This can be estimated from table using the longest length of run from the must remote part of the catchments to the outlet and the gradient of the land, from the topographical map, the longest length of run = 316.35m

the gradient of the area = 5.0%

Interpolating this from the table gives the value of the concentration time

t_c = 6minute

:- $Kn = A + B \log_{10}N$

$= 3.280 + 2.340 \log_{10}10 = 5.62.$

$$I = \frac{Kn}{(t_c + a)^b} = \frac{5.062}{(60/60 + 0.600)^{0.9520}} = 7.89\text{mm/hr}$$

To estimate the rainfall intensity for Abuja, the value 7.89mm/hr, which is the rainfall intensity for Ikeja, must be multiplied by a proportionality factor, which is given by;

$$\frac{\text{Maximum mean annual rainfall for Abuja}}{\text{Maximum mean annual rainfall for Ikeja}}$$

$$\text{Proportionality factor} = \frac{1,441.30}{1,588.90} = 0.9071$$

:. Rainfall intensity for Abuja is given as;

$$I = 0.9071 \times 7.89 \text{ mm/hr}$$
$$= 7.16 \text{ mm/hr}$$

Now total runoff for the catchments

$$Q = \frac{C\,I\,A}{360} \quad (m^3/s)$$

$$= \frac{0.60 \times 7.16 \times 6.75\text{ha}}{360}$$

$$Q = 0.08 \text{ m}^3/\text{s}$$

From the continuity equation;

$Q = AV$

Where Q = Total runoff (discharge)

A = cross sectional area of channel

V = velocity of flow through channel

4.10 CHANNEL DIMENSIONS

The channel must be proportional to carry the design run off at average velocity less than or equal to the permissible velocity. This is accomplished by the application of the manning formula

Flow velocity

$$V = \frac{R^{2/3} S^{1/2}}{n} \quad \text{(from Mannings equation)}$$

Where;

V = velocity of flow

n = roughness coefficient

R = cross sectional area divided by the wetted perimeter of channel given as A/P

S = slope of the drainage channel

For a trapezoidal channel, cross sectional area:

$A = bd + zd^2$

And the wetted perimeter:

$P = b + 2d\,(z^2 + 1)^{1/2}$

Where,

b = bottom width of the channel

d = design depth of the flow

For small drainage, a bottom width of 1.2m is recommended.

To design an appropriate channel to carry the design discharge, series of depth have to be assumed till the best value is arrived at.

First assumption;

Let depth (d) = 0.5m

Hydraulic radius

$$R = \frac{A}{P} = \frac{\text{cross sectional area}}{\text{wetted perimeter}}$$

$$= \frac{bd + zd^2}{b + 2d\,(z^2 + 1)^{1/2}}$$

given b = 1.2m
z = 1.5
d = 0.5m

$$R = \frac{1.2x0.5 + 1.5\,(0.5)^2}{1.2 + 2\,(0.5)(1.5^2 + 1)^{1/2}}$$

$$= \frac{0.\ 975\ m^2}{3.03\quad m^2}$$

R = 0.32.

4.11 HYDRAULIC RADIUS

Hydraulic radius calculated (R) = 0.32 m

Side slope of channel (s) = 1.5 (from table)

Roughness coefficient (n) turn table = 0.60

4.12 Velocity of flow

$$V = \frac{R^{2/3}\ S^{1/2}}{n}$$

$$= \frac{0.32^{2/3}\ x\ 0.05^{-1/2}}{0.60}$$

V = 0.17m/s

From continuity equation, discharge calculated using the channel dimensions should be equals to or more than the total discharge expected from the run off.

That is

$Q = AV$

$= 0.0.975\ m^2 \times 17 m/s$

$= 0.17 m^3/s$

$0.17 m^3/s > 0.08 m^3/s$

Hence, calculated discharge is greater than designed discharge. This means the channel depth chosen is adequate but uneconomically to much. Redesigned.

Second trial, reduce depth (d) = 0.4m

4.13 Hydraulic Radius.

$R = A/P$

$$= \frac{bd + zd^2}{b + 2\,d\,(z^2 + 1)^{1/2}}$$

$$\frac{1.2 \times 0.4 + 1.5\,(0.4)^2}{1.2 + 2(0.4)(1.5^2 + 1)^{1/2}}$$

$$\frac{0.72\ m^2}{2.64 m}$$

$R = 0.27 m$

4.14 Velocity of flow

$$V = \frac{R^{2/3}\,S^{1/2}}{n}$$

$$= \frac{0.27^{2/3} \times 0.05^{1/2}}{0.60}$$

V = 0.16m/s

For continuity

Q = AV

$= 0.72m^{1/2} \times 0.16m/s$

$Q = 0.12\ m^{3-}/s$

$0.12\ m^2/s > 0.08m^3/s$

The sand assumed depth of 0.4m is also adequate but still not economical and can still be reduced further.

Third assumed depth

Let d = 0.34m.

4.15 HYDRAULIC RADIUS

This is given as

$$R = A/P = \frac{\text{Cross sectional area}}{\text{Wetted perimeter}}$$

$$\text{i.e, } \frac{bd + zd^2}{b + 2d\,(z^2 + 1)^{1/2}}$$

From all data analysis;

b = 1.2m

d = 0.34m

z = 1.5

$$:. R = \frac{1.2 \times 0.34 \times 1.5\ (0.34)^2}{1.2 + 2(0.34)(1.5^2 + 1)^{1/2}}$$

$$R = \frac{0.58}{2.43} \qquad = 0.24m$$

R = 0.24m (calculated)

S = 1.5, chosen from table based on soil type

n = 0.60, chosen also from table based on soil characteristics

:. Velocity of flow through the channel

$$V = \frac{R^{2/3}\ S^{1/2}}{n}$$

$$= \frac{0.24^{2/3} \times 0.05^{1/2}}{0.60} \qquad = 0.14m/s$$

For the appropriate values of R and V to be obtained, series of values for channel depths have to be assumed using trial and error till best value is arrived at For continuity, discharge calculated from channel dimension and flow velocity must be equal or more than discharge calculated using hydrological and soil data collected from the field.

Q = A V

$= 0.58m^2 \times 0.14m/s$

:. Channel section is adequate

4.16 FREEBOARD

Freeboard is meant to provide a margin of safety, should in case the actual discharge exceeds the designed discharge capacity of the drainage channel. This is in conformity with common engineering practices of providing a factor of safety for every design.

For a drainage channel design; the recommended freeboard is 20% of the design depth

i.e. Freeboard = 20% depth

$$= \frac{20}{100} \times 0.34m$$

$$= \frac{0.34m}{5} = 0.068m$$

Total depth of channel

D = design depth + freeboard

= 0.34m + 0.068m

D = 0.408m

4.17 TOTAL DRAINAGE CAPACITY

Total drainage capacity according to Benoulli is given of Q = AV

From Manning equation

V = R 2/3 S ½

But R = A/P

$$= \frac{bd + zd^2}{B + 2d\,(z^2+1)^{1/2}}$$

$$\frac{0.739}{2.671}$$

$$= 0.28m$$

From manning equation

$$V = \frac{0.28^{2/3} \times 0.05^{1/2}}{0.60}$$

$= 0.16$ m/s

Total drainage capacity = $0.739m^2 \times 0.16m/s = Q = 0.12m^3/s$

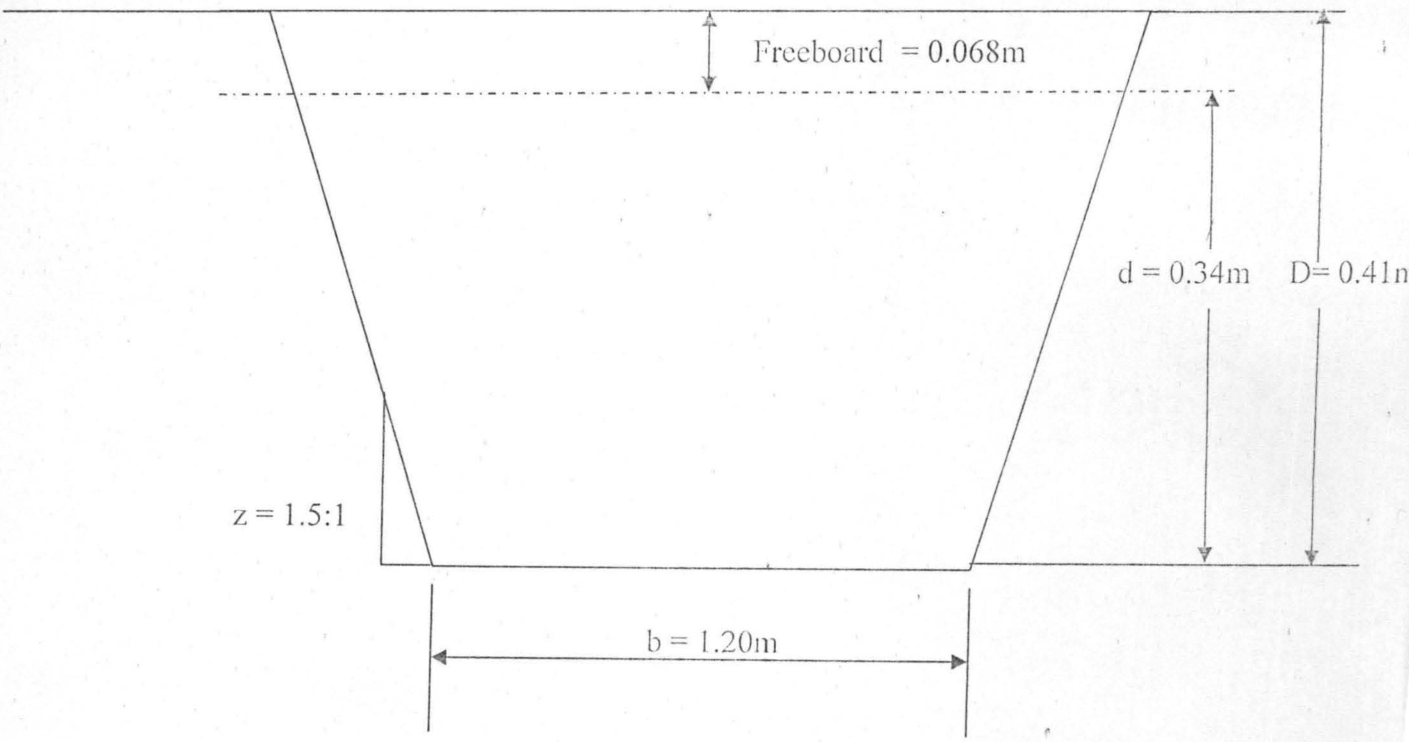

Fig. 4.2 Cross section of the design open channel

4.18 MAINTENANCE OF OPEN CHANNELS.

The major problem in the maintenance of open drains is the removal of sediments and vegetation from the drains. Growth of weeds and other aquatic plants in the drains greatly retards the velocities of flows thereby decreasing the drains capacity.

Silts and clay sedimentation in drains also restricts flow of water. Manual labour is normally employed to clean the drains.

Mechanical methods by the use of bulldozers, draglines, excavators, or tractors. Chains is also effective for cleaning the drains. Herbicides chemicals such as aromatic solvents are very effective in killing aquatic weeds.

CHAPTER FIVE

5.0 RESULTS AND DISCUSSION

In an attempt to design an appropriate drainage channel for draining the ponded water from the farm under study, some tests and analysis were carried out with the following results

5.1 Rainfall

An average rainfall figure of 1,441.3mm as recorded in the year 2000 in table (1.1) shows that Abuja experiences a high rainfall. This high rainfall coupled with the fact that the farm consists of a low laying area in the middle of the surrounded by well drained areas, 70% of the run off from the farm empties into low laying area without any adequate flow outlet.

5.2 Temperature and Humidity

Abuja is a typical tropical environment characterized by high temperature and relative humidity. From the climatic data collected from the F .C. T. Agricultural Development project meteorological unit, an average yearly temperature of 34oC and relative humidity of 79% shows that evapotranspiratic which is one way by which soil can be relieved of excess water will be greatly affected (slowed down) .

This factor is responsible for the high moisture content of the soil, which the other hand affects the infiltration rate of the soil.

5.3 Soil

From the soil analysis of the land results showed that the soil contains a high percentage of clay in relation to silt and sand. This gives a clear reason as to why the low laying areas are always flooded or waterlogged especially during the rainy season.

Field investigation conducted on the farm showed that the water table was below 50cm deep.

5.4 Design Parameters and Discharge.

From the test result conducted on the soil and the hydrological data obtained, the following design parameters where arrived at:

1. Rainfall intensity of 7.16mm/hr
2. Land calculated to be 6.75ha
3. land slope = 5%
4. Site slope of channel = 1½:1
5. Roughness coefficient = 0.60

Using the parameters and an appropriate bottom width and channel depth (D) a total discharge expected from the farm in m^3/s was calculated as 0.080 m^3/s.

Rainfall in Abuja can last for as long as 1½ hours (5400s). A discharge of 0.080m^3/s lasting for 54000 seconds can accumulate to 0.080 x 5400 432m^3. If this occurs for up to 3 or 4 times in a week without any discharg outlet, it can cross great damage to crops.

For this drainage to be constructed, an estimated sum of N2.8m expected to be spent. This includes cost of survey, materials, labour as w as other overhead cost.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Excess water (surface ponding), when allowed to stay over a long period of time will lead to

1. Saturation of the entire soil profile due to impeded percolation or due to high water table.
2. Retarded crop growth and
3. Difficultly in carrying out farm operations especially using machineries.

This project was carried out to identify the real course of surface ...ding on the farm under study and to design and recommend the ...t appropriate and efficient drainage system for better crop yield. ... Result obtains from climatic analysis, soil analysis and land ...gation help in the assessment and identification of the most ...ical drainage method for the farm. One cannot overemphasize the ...r removing excess water from agricultural land through the ...n of good drainage system. This will go along in actualizing the ... Governments dream of achieving self-sufficiency in food ...n.

... proper drainage systems put in place, no part of the land in ... will be left unutilized or uncultivated because of water logging.

of this land reclamation. Project may be high, the economic benefit in the long run will be greatly appreciated.

6.2 Recommendations.

The following recommendations will provide efficient drainage system;

1.For good agricultural production, farmlands should be provided with good drainage systems.

2. Outlet drains must be large enough to carry designed discharge quickly from land.

3. Design and layout of field drains should be strictly adhered to.

4. Surface drainage should make room for farm operations (machines of various types).

5. Proper cleaning of the drains should be done to avoid flow obstruction.

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