ANALYSIS OF SEEPAGE LOSSES IN EARTH DAMS USING FLOW NET. A CASE STUDY OF TAIGWAI DAM

BY

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MATRICULATION: NO: 2004/18689EC

DEPARTMENT OF CIVIL ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE, NIGERIA.

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A THESIS SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN CIVIL ENGINEERING.

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JANUARY, 2010.

DECLARATION.

Samuel Sabo Zemo declare that this project has been written by me under the able upervision of Engr Richard Adesiji and all the materials consulted have been duly cknowledged by means of reference. I take sole responsibility of all Issues there in.

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AMUEL SABO ZEMO   DATE.

004/18689EC

CERTIFICATION

s research work has been read and approved as meeting the requirement of the award the degree of Bachelor of Engineering in the department of Civil Engineering, Federal iversity of Technology, Minna.

-- 12-02-2010

GR. RICHARD ADESIJI DATE

ROJECT SUPERVISOR)

-- ----------------------------

GR. (DR.) SADIKU DATE

EAD OF DEPARTMENT)

-- ----------------------------

TERNAL SUPERVISOR DATE

DEDICATION

his project work is dedicated to ALMIGHTY GOD, the creator and also to my caring arents, MR& MRS SABO ZEMO for their moral and financial support.

ACKNOWLEDGEMENTS.

cere gratitude goes first to our Lord and Saviour Jesus Christ who has been there e through it all. I am indeed very grateful to my supervisor Engr. Richard Adesiji time, patience and understanding despite his busy schedules.

e Head of Department Dr Engr S, Sadiku and my Civil Engineering Department es Dr Jimoh, Dr Amadi, DR Auta , DR Chado, Engr P.N Ndokwe, Mal Mustapha, James, Engr Kudu, Engr Aguwa, Engr Adulkadri Mr Kolo, Mr Alhaji, Mrs Gbadebo, he rest of my lectures, for guiding me through my educational pursuit. May God bless ll? Amen.

sincere thanks goes to my parents Mr & Mrs Sabo Zemo for their care morally and ncial support through my studies. My thanks goes to all my sibling, my lovely sister me, Christiana, Patience, Pamela, Christopher, Godiya,and Jessica. My special thanks s also to my in-law Mr & Mrs Gambo Kisha for their moral support, a big thanks goes Dr & Mrs Williams Zemo, also to my cursing, Shunum, Ben, John, Alex, Joyce, Yosi, ya, Charity, Vicky, Bamani, for their advice and continuous prayers. My appreciation s to my humble uncles Mr & Mrs Bako Kato for his support without him on my side addmition would have not been possible, also to the rest of my uncle Mr & Mrs thony Kuh, Mr & Mrs Nathan Kuh, and Mr & Mrs Adamu Jatau for their advice. My ecial thanks to my friends Anto, Iaiah, Yakubu, Musa, Michael, Jey, Ikechuku, Monday, ctor, Sule, Jonathan, Dogara, Isah, Patience, Mary, Sylvia, Blessing, Inze, and all 2009 andaunt and others who made one

ontribution or the other to my success thanks for being there for me.

ABSTRACT.

project study was aimed at determining the seepage pattern and discharge volume ıgh the Tagwai dam. The analytical method of flow net was used for the analysis of eepage loses, from the sieve analysis carried out; it was observed that the base dation of the dam is a fine sand. And the moisture content was found to be 10%, at end of the day, a discharge value for seepage Q, was found to be 7818528.1104 s/year.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The earth dams can be constructed on almost all types of foundations provided that sub – surface strata have been thoroughly investigated and the design has been adopted to suit the foundation. The foundation of the earth dam should provide a suitable support the dam under all conditions of saturation and loading. Moreover, it provides sufficient resistance to seepage to prevent piping failure and excessive loss of water. When designing any engineering project, engineers must decide how conservative they should be. Casagrande (1965), in summarizing his comprehensive, analysis of this question as relates to earthworks. When earth dams fail, the consequences are likely to be great property damage because of the sudden release of a large volume of water, often with little or no advance warning. About one quarter of the failures of dams and reservoirs are caused by seepage problems (Middle brooks, 1953), which indicate high level of uncertainty in the design of seepage-control measures. This serves to emphasize the importance of analyzing seepage and designing effective measures for its control. Before the advent of modern soil mechanics, dam were designed principally on the basis of rule of thumb that had evolved from previous experience but that were not based on a fundamental understanding of hydraulic mechanical principles involved. The historic work of Terzaghi (1925) and the lucid explanation of Casagrande (1961) have contributed substantially to a more rational design of earth structures within the past few decades. Many other have contributed to the development of the analytical and experimental method now in use. Experienced seepage and drainage engineers usually look upon these methods as means for establishing the other of magnitude" of the problem. When used in this way, the analytical and experimental methods of modern soil mechanics can be useful tools to earth dam designers. If used in any other way, they are likely to lead to catastrophic surprises. Earth dam's designers should not allow themselves to be deluded into believing that seepage through dams and their foundations will be automatically controlled if some kind of seepage control is specified. Controlling seepage through dams will always present challenges to even the most astute and experienced designers, because water will always find the paths of least resistance through pervious strata, joints, and seams as they really exist, rather than as they are assumed to be for this reason, every important dam should be instrumented with piezometer, observation wells, and seepage-measuring devices. Adequate instrumentation and observation of completed earth dams and the correction of any unsafe or questionable condition is an important part of the overall design process.

1.2.1 Aims and objectives

The aim of this work is to study the seepage loss in earth dams and comparing with the seepage flow obtained from the analysis using flow net.

1.2.2 The objectives of this project is to

i. Classify the soil available in the study area

ii. Determine the moisture content of the soil at different period of time.

iii. To study the flow pattern of the seepage through the Tagwai dam

iv. Determine the seepage pattern and discharge volume through the Tagwai dam.

1.3 Justification

The research has being carried out to determined seepage loss in Tagwai dam, using flow net. Therefore methods for analyzing the influence of seepage loss will be among the most important aspects of designing safe dam. In order to maintain the stability and safety of earth dam it is important that seepage flow should be monitored in order to avoid sudden collapse of dams.

1.4 Statement of research problems

Seepage is one of the major causes of dam and reservoir failure; if proper care is not taken it would lead to loss of life and property. (Middlebrook, 1953).

When earth dams fail, the consequences are likely to be great loss of life and great property damage because of the sudden release of a large volume of water often with little or no advance warning. All dams have some seepage as the impounded water sucks paths of least resistance through the dam and its foundation and must be controlled in both velocity quantities.

1.5 Scope of Work

The scope of this research work is to estimate seepage loss in Tagwai dam using flow net.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definitions of terms

2.1.1 Earth dam

Earth dams are dams constructed mainly from earth (or soil), where earth dams are use for the storage of water for irrigation, and has been built since early time. However, earth dams are of low height, as these were designed by empirical methods and their construction was base on the experience. Developments of soil mechanics and new constructed techniques have been helpful in creating confidence among the engineers to build dams of very large heights. Some of the high earth dams are Nurckdarp USSR (310), Mica dam, (244m), Oroville dam, USA (3235m) and Tehri dams Indian (261m). And earth dam is composed of fragmental material. An earth dam has an impervious membrane to check the seepage of water through it. Earth dam has the origin about a hundred years ago. Since then several earth dam have been build.

Earth dam can be constructed on almost all type of foundations provided suitable measures are taken. The earth dam is more suitable than gravity dams if strong foundation at a reasonable depth is not available at the construction of a gravity dam. Earth dam are usually cheaper than gravity dams if the soil in abundant quantity is available near the site. Modern developments is earth moving equipment have resulted in decreased cost for the dams. (Wikipedia)

2.1.2 Seepage through earth dams

Seepage is the gradual percolation of water through dam abutment or its foundation. Contrary to popular opinion, wet areas downstream from dams are not usually natural springs but seepage areas. Flow from groundwater springs in existence prior to the reservoir would probably increase due to the pressure caused by a pool of water behind the dam. All dams have some seepage as the impounded water seeks paths of least resistance through the dam and its foundation. Seepage must, however, be controlled in both velocity and quantity. Seepage can emerge anywhere on the downstream face, beyond the toe or on the downstream abutments at elevations below normal poll. Seepage may vary in appearance from "soft", wet areas to a flowing "spring". It may show up first as area where the vegetation is lush and darker green. Downstream groin areas (the areas where the downstream face contacts the abutments) should always be inspected closely for signs of seepage. Seepage can also occur along the contact between the embankment and a conduit spillway, drain, or other appurtenance. Slides in the embankment or an abutment may be the result of seepage causing soil saturation or pressures in the soil pores, by (Harry R. Cedergren). At most dams, some water will seep from the reservoir through the foundation. Where it is not intercepted by a subsurface drain, the seepage will emerge downstream from or at the toe of the embankment. If the seepage forces are large enough, soil will be eroded from the foundation and be deposited in the shape of a cone around the outlet. A continuous or sudden drop in the normal lake level may be an indication that seepage is occurring. In this case, one or more locations of flowing water are usually noted downstream from the dam. This condition, in itself, may not be a serious problem. But will require frequent and close monitoring and professional assistance. The need for seepage control will depend on the quantity, content, and/or locations of seepage. Controlling the quantity of seepage that occurs after construction is difficult and quite expensive. (Wikipedia)

2.2 Piping through dams.

Some seepage is inevitable through all earth dams. If the seepage is controlled, it does not cause any harm other than loss of water. However, if the seepage is uncontrolled and concentrated, it may lead to piping and subsequent failure of the earth dams. About 23% of the total failure occurred in the past were piping failures. Piping is the progressive backward erosion starting from the exit point and subsequent removal of the soil from within the body of the dam and the formation of pipe–like conduit inside the dam. Piping occurs when the seepage force is very large and concentrated flow occurs. It begins at a point where the water seeping through the dam emerges at the downstream face. As water seeps through the dam, the pressure head gets dissipated in overcoming the frictional resistance of flow. In case there is not enough dissipation of pressure head, the seepage water emerges at the downstream face under high pressure and with a high velocity and the soil particles are carried away by the water. Piping starts at the downstream face and gradually progresses towards the upstream because when some soil has been removed, the hydraulic gradient further increases. The process continues and ultimately a pipe-like conduit is formed and rush of water and soil occur leading to piping failure.

The erosion of soil particles by seepage forces is opposed by resisting forces developed in the soil. These resisting forces depend upon the cohesion and interlocking effect of the soil, the weight of the soil and the action of the downstream drains. If the resisting forces are greater than those causing erosion the piping does not occur.

On the other hand, if the resisting forces are smaller than those causing erosion, the particles are washed away and a small hollow pipe (or tunnel) is formed through the dam. The tunnel formed gradually enlarges as more and more soil particles are carried away by water and ultimately the failure of the dam occurred. By Dr K.R Arora (2002)

2.3 Effects of seeping water

Water is known to be an inert substance, yet seeping water can either increase or decrease soil permeability. In situations where changes in permeability under the influence of seepage could be detrimental, chemical analysis should be made of reservoir water and of soil to safeguard dams and reservoir against failures caused by the loss of suspended or dissolved matter by seeping water, seepage quantities should be measured periodically and samples tested for suspended solids and dissolved matter.

2.4 Seepage control measures

Earth dams and their foundations can be protected from seepage fundamental processes which include the following.

- Use of upstream blanket in seepage control.
- Use of relief wells in seepage control
- Description of relief wells
- Use of relief wells
- Use of filters and drains in seepage control

2.4.1 Use of upstream blanket in seepage control.

Relatively impervious compacted earth blankets are frequently placed upstream of dams to lengthen the seepage flow path and thereby reduce the exit gradient and quantity of under seepage discharge. It also permit cutoff to be placed at some distance from the dam, if such a location were feasible or economical as may be the case because of the natural slope of the bedrock. If the blanket is very impervious compared to the natural foundation, the reduction in the seepage quantity and pressures at the downstream toe is directly related to the length and thickness of the blanket. Good practice for a blanket which is relied upon to control the under seepage required that it be constructed of impervious soil like of impervious core of the dam. It also has to completely cover the permeable strata exposed to water pressure.

At some dams, nominal blankets have been constructed by dumping impervious soil (sometimes waste stripping or other materials) in a random manner and compacting by the travel of the hauling equipments. At other sites, a natural surface blanket of impervious material already exists. And it is necessary only to fill the holes or gaps to make a continuous seal, in such case at least the upper surface of the natural blanket should be scarified brought to a good water content and compacted.

2.4.2 Use of relief wells in seepage control.

Historically, relief wells are often installed to relive subsurface hydrostatic pressures in pervious foundation strata overlain by more impervious top strata, conditions which often exist landward of levies and downstream of dams and various hydraulic structures.

Relief wells can also be used to relieve hydrostatic pressure that may develop within semi confined and confined aquifers due to rising water tables and pressure in these aquifers.

This pressure might otherwise subject large areas of the landscape to act as discharge zones and cause land degradation. Relief wells, in essence are nothing other than control of artificial springs that reduce pressures and prevent the expansion of discharge areas and removal of soil via piping.

2.4.3 Description of relief wells.

Pressure relief wells refer to vertically installed wells consisting of well screen surrounded by a filter material designed to prevent the aquifer materials entering .the well. A typical relief well is shown in fig 4. The wells including screen and riser pipes have internal diameter generally between 10mm and 60mm, sized to accommodate the maximum continuous discharge. Well screens generally consist of wire-wrapped steel or plastic pipe, slotted or perforated steel or PVC pipe.

2.4.4 Use of relief wells

The use of relief wells includes the following.

- Relive of excessive hydrostatic pressure, placing the wall outlets in trenches or collector pipes below the soil surface serve to dry up seepage areas downstream of levees and dams. Relief wells are often used in combination with other under seepage control measures, such as upstream blankets, downstream seepage and grouting.
- Provision of flexible control measures as the systems can be easily expanded if the initial system is not adequate. Also the discharge of existing wells can be increased by pumping if need arises.

A relief well system requires a minimum of additional real-estate as compared with other seepage control measures. However wells require periodic maintenance and frequently suffer loss in efficiency with time for a variety of reasons such as clogging of well screens by intrusions of muddy surface waters, bacterial growth or carbonate incrustation and iron deposition. Relief wells may increase the amount of under seepage that must be handled at the ground surface, and means for collecting and disposing of their discharge must be provided. Adequate systems of piezometers and flow measuring devices must be installed to provide continuing information on the performance of relief well systems.

2.4.5 Use of filters and drains in seepage control.

Filters can provide permanent security against damaging actions of seepage and ground water where certain fundamental requirements are strictly enforced. To prevent the movement of erodible soils and rocks into or through filters the pores spaces between the filter particles should be made small enough to hold some of the large particles of the protected material in place (Taylor, 1948). When all seepage discharge areas are covered with well designed filters and drains, piping problems can be virtually eliminated. These filters are made of porous materials whose openings are small enough to prevent the movement of soil into the drains and which is sufficiently pervious to offer little resistance to seepage.

In order to relieve hydrostatic pressure and reduce uplift of the base of the dam and the foundation, it is frequently advisable in seamy rock and always for high dams to drill a line of holes downstream from the previously placed grout curtain to carry away seepage water which may pass the curtain. The drainage holes are connected to a drainage gallery or other means to carry the seepage to tail water and also carrying away harmlessly any seepage which pass under the dam.

2.5 The flow net

Water tends to follow, the shortest path from point to point but at the same time is assumed to make only smooth curves when it changes direction. The flow line stretches bundles of rubber bands that extend from point of greater head to point of lower head. In many cases the curves are segments of eclipse or parables. The 'different amount of energy or head can be represent on the same picture by equipotentials lines which are lines that indicate contours of equal energy. The flow line cross them at tight angles since the water moves from high energy level to lower energy level along paths of maximum energy gradient in the same way water flows down a full size from high level to lower levels following the steepest paths. The pattern of flow and equipotential lines is termed the flow new and it is powerful tool for the solution of seepage problems.

The flow lines and equipotential lines meet at a right angle to each other. Because the phreatic line is also a flow line the equipotential lines intersect it at right angle. Since the pressure at the phreatic line is zero the successive equipotential line make equal vertical interception the phreatic line. The discharge between any of two adjacent flow lines is constant.

2.5.1 Flow net construction

Once the phreatic line in an earth dam has been dawn, the flow net can be obtained. The phreatic line represents the top hydraulic boundary of the seepage flow. In practice, generally the graphical method of flow construction is used. The electrical analogy method is also sometimes used. Both these methods are discussed below.

1. **Graphical method**

The graphical method makes use of the properties of the flow net. The flow net is drawn by trial and error. First a rough flow net is drawn and then it is modified successively till a good flow net is obtained.

Properties of the flow net

1. The flow lines and equipotential lines meet at right angles to each other.

2. Because the phreatic line is also a flow line, the equipotential lines intersect it at right angles

3. Since the pressure at the phreatic line is zero the successive equipotential lines make equal vertical intercepts on the phreatic line.

4. The flow fields obtained by the intersections of the equipotential lines and the flow lines are approximately squares in shape. A circle can be approximately drawn in each square field touching all the sides of the square.

5. The discharge between any two adjacent flow lines is constant.

6. The potential drop between any two adjacent equipotential lines is also constant

7. The smaller the dimension of the flow field is the hydraulic gradient and the velocity of flow through it.

8. In a homogenous soil, every transition in the flow lines and equipotential lines is smooth and gradual.

2.5.2 Determination of flow from flow net

The total quantity of water Q flowing through a unit width of a soil mass is equal to the sum of the sum of the quantities in all the flow paths of the flow net. But it is a basic requirement of a flow net that every flow path must transmit the same quantity of water.

Therefore the quantity in each flow path which will be designated as ΔQ, must be equal to the total flow divided by the number of flow paths. Likewise, the total head h is the sum of the drops in head in all the equipotential spaces of the flow net; and the drop in head in each such space, which will be denigrated as Δh, must be equal to the total head divided by the number of equipotential spaces.

In the case of the flow net shown in fig 2, the flow through any single square is ΔQ and the drop in head is Δh. Applying the Darcy law, Q=kiA, to this arbitrarily selected square and remembering that the cross sectional area through which flow takes place is equal to the height S, of the square times unity, we may write. By (Milton E. Harry) Purdue university

$$\Delta Q = \frac{K \Delta h S}{l} \quad \text{- - - - - - - - -i}$$

Since the figure are squares,

$$\frac{S}{l} = 1 and \qquad \text{ii}$$
$$\Delta Q = K \Delta h$$

If the complete flow net has N spaces between equipotential lines, then

N Δh=h or $\Delta h = \frac{h}{N}$ - - - - - - - - - - iii

The flow through any square, and thus through any flow path is

$$\Delta Q = \frac{Kh}{N} \quad \text{- - - - - - - - - IV}$$

Also, if there are F flow paths is the net

$$\Delta Q = \frac{Q}{F} \quad \text{V}$$

Then the total flow through all the flow paths is

$$Q = Kh\left(\frac{F}{N}\right)$$

$$OR\ Q = Kh\left(\frac{N}{NE}\right) \quad \text{VI}$$

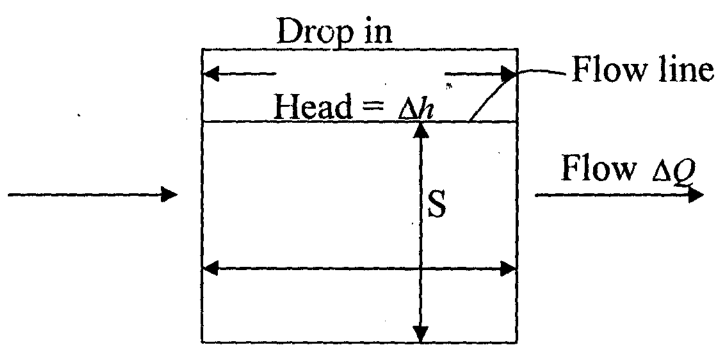
Where Q = Total discharge or flow

K = Coefficient of permeability

h = Total head differential through the dam

NF = Number of flow paths

Ne = Number of equipotential drops



Enlarge Sample X

Simple flow NET

Figure 2.1 show a simple flow net

2.5.3 Pheatic line for zoned earth dam with central core

Fig 2.1 shows a zoned earth dam with a central core of the impervious soil as silty clay. The outer shells are constructed of previous material such as sand and gravel. As the ration of the permeability of the material of the shell and core is very large, the effect of the outer shells on the phreatic line in the core is negligible. As such the upstream shell has practically no effect on the position of the phreatic line. The phreatic line can be assumed to start from point B where the water level cut the core. The downstream shell in this case acts as a drain. Because the permeability of the core material is very low as compared to that of the shell material, it is the usual practice to draw the phreatic line only for the central core section, where the focus F of the

Base parabola is located at the d/s toe of the core.

For drawing the phreatic line it is assumed that the reservoir is extended up to the point B on the u/s face of the core. The phreatic line is then drawn for the core section, the focus F of the base parabola is at the d/s toe of the core. The starting point A is located at the distance of 0.3L from the point B, where L is the horizontal projection of the wetted portion of the upstream face of the care. The phreatic line BE, MY is drawn exactly after making the correction and the exits correction. However, in this case, the phreatic line at the exits end will be slightly above the base of the core so that the seepage water can flow under gravity through the d/s shell which acts as a drain. Dr.Arora, K.R, (2002)

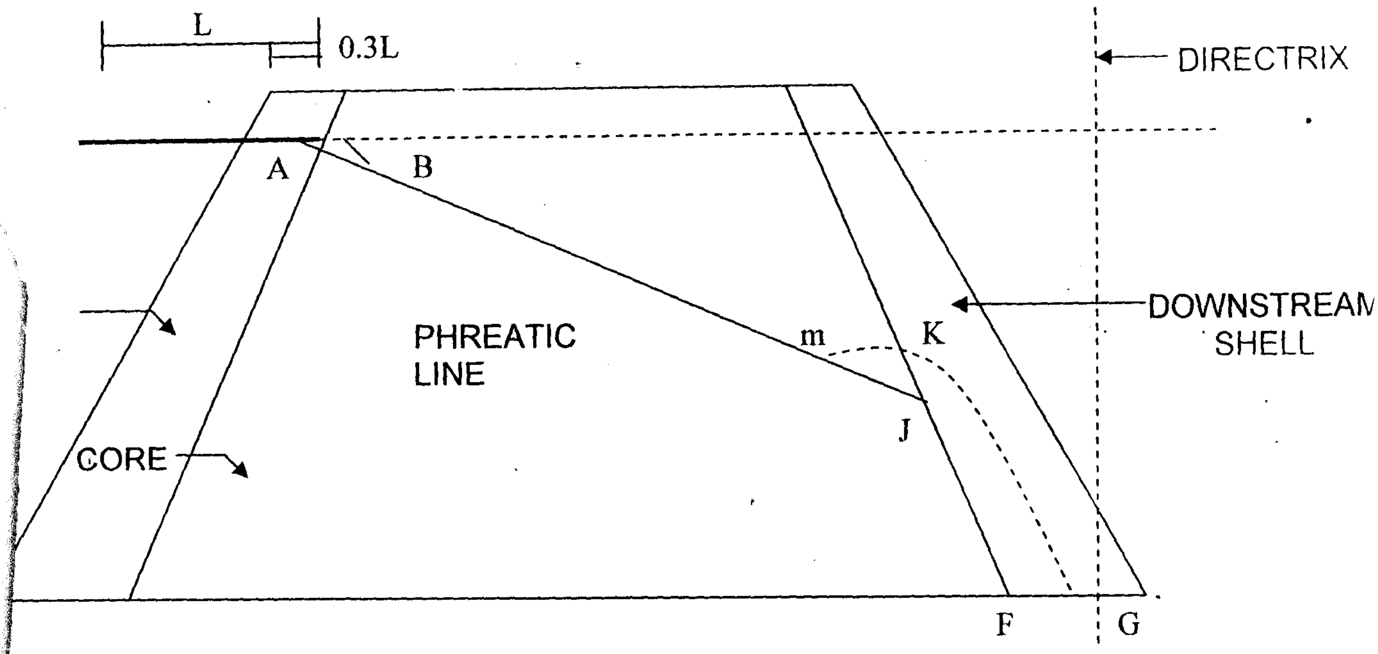


Figure 2.1 Phreatic line diagrams

2.6 Description of the dam

Tagwai dam is a homogenous zone earth fill dam sitting on and impervious foundation, the dam is sited across river chanchaga, in chanchaga local government in Niger state Nigeria, with Catchment area of the dam -250,078km^2, average annual precipitation-1270mm average annual runoff-25x10^{6}m^3, crest length-1,770m, crest level 259m O.D, free board-4.0m,maximum flood level-257.5m O.D, full supply level-256m O.D, crest width-10m,maximum structure high-25m O.G.L, hydraulic height-21m, maximum width of base-150m, total storage capacity -84x10^{6}m^3, dead storage level-244.90 O.D, dead storage capacity-1.8x10^{6}m^3, surface area of lake 550ha, total volume of earthworks-870,000m3, spillways uncontrolled concrete ogee section, main spillway 50m long, crest elevation 256m O.D, together with and uncontrolled natural emergency spillway at a level above 257.20m, O.D at far end of right bank embankment. Intake and outlet works submerged uncontrolled intake structure with 3m, square fixed trash tracks. Penstocks are

240.24" (inches) dial steel pipes with concrete surrounds. Outlet control works comprise of 24" dial guard and control values with a downstream concrete stilling basin.

BENEFITS: providing source of raw water supply for expansion of Minna water supply up to 12 million gallons per day, fisheries, minimunı irrigation, wide life conservation and recreation. Cost of dam, head works, 8.3km access road, staff houses and resettlement #6,960,000.00.

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1 Sieve analysis

Sieve analysis was carried out on the dam foundation in other to determine the particles size of the dam foundation.300g of soil sample was weight and soak for about 12 hours and the sample was sieve washed through sieve 2.0mm and 0.75mm in other to remove all the clay particles that are there in the soil. The remaining soil or particles left are dry in the oven for about 24 hours under the temperature of 105°C, where sieve set with known masses descending in aperture size from sizes 5.00mm to 0.75mm. The set of sieves were placed on a mechanical sieve shaker and was vibrated for about 5 to 10 minutes, the weight of each sieve + the mass of soil it retains were taken and recorded property, the percentage mass retained, cumulative percentage mass retained and the percentage passing were calculated by the formula below

$$\%\,mass\ retained = \frac{weight\ of\ sample\ retained\ on\ a\ sieve \times 100}{weight\ of\ original\ sample}$$

% passing = original weight – weight retained on sieve that is

% passing = Total cumulative mass retained – weight retained on individual sieve.

Cumulative percentage (%) mass retained = summation of percentage (%) Mass retained.

3.2 Natural moisture content determination

Two moisture content cans were weight empty and fresh soil sample i.e. (distribution sample) was placed in the cans as soon as they were collected from site. The samples were placed in an oven for 24 hours for the sample to dry property; under the temperature of 105°C. The dried samples were removed from oven and new weights are being carried out and recorded properly. The weight of water in the soil and that of the solid were obtained by differenced in weight using the relationship below. Thus the natural moisture content was determined

$$M = [(M_2 - m_3)/(m_3 - m_1)] \times 100$$

Where m= Natural moisture content

m1 = Weight of empty can (g)

m2 = weight of can + west sample.

m3 = weight of can + dry sample

Therefore (m2 – m3) = weight of water

(m3- m1)= weight of solid

$$M = \frac{weight\ of\ water}{weight\ of\ \mathrm{Solid}} x100$$

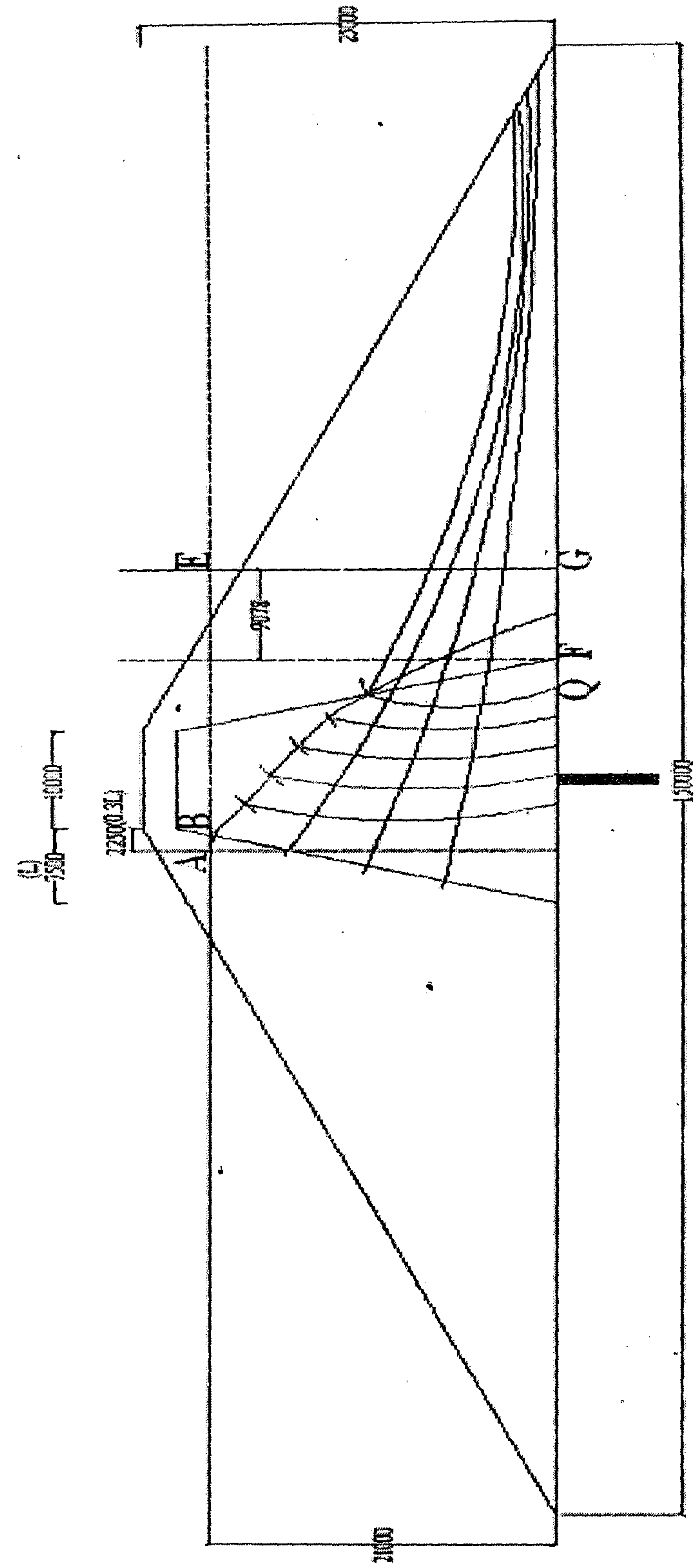


Figure 3.1 show a flow net construction

The flow net show the flow line and equipotential line which are line of constant head, of the Tagwai dam where the number of flow line is estimated to be 4, while that of equipotential line are 6. The distance from the directrix to focus that is from F to G zo=9.078cm, where the dam discharge is estimated.

3.3 Procedure for flow net construction

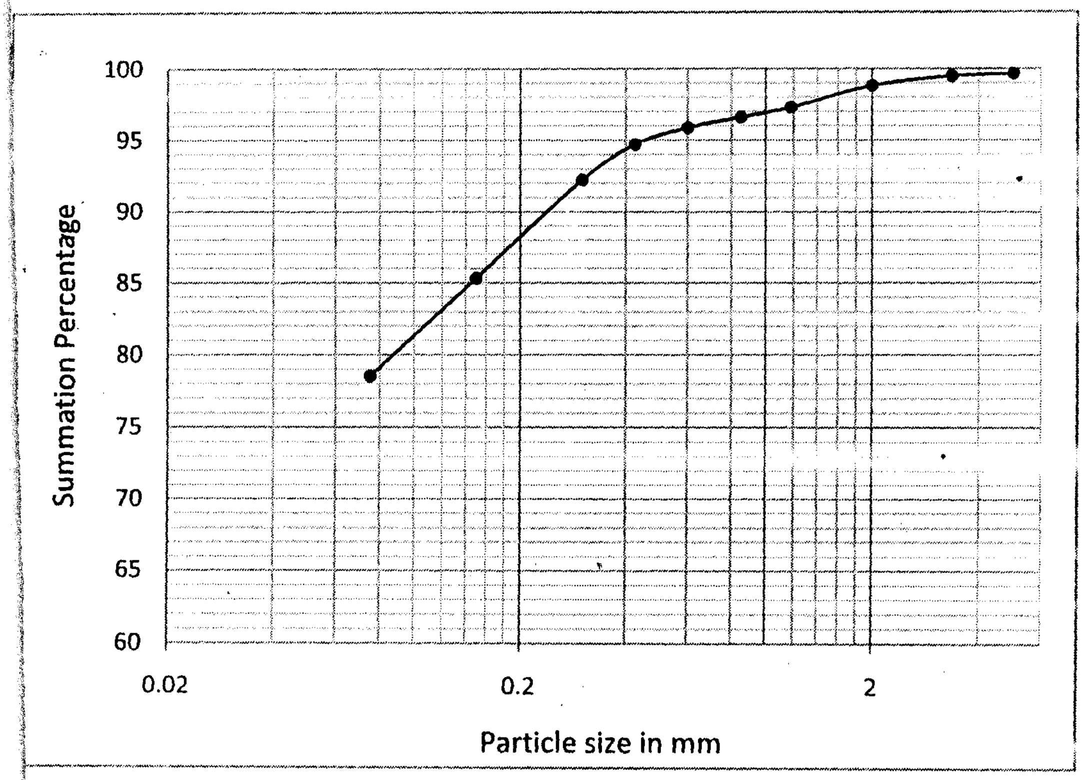
1. The phreatic line was approximated as a parabola with focus F located at the bottom of flow line and the downstream equipotential.
2. Point A was located on the water surface where AB = 0.3B C; point G was located on the direction of the parabola located as distance z_o flow.
3. Point E located half way between point F and G. Also point K was located where $\overline{KF} = \overline{FG} = z_o$.
4. The phareatic surface was sketched as a parabola passing through point face E, K and A. the line was adjusted to interest point B on the upstream face of the dam.
5. The equipotential line was sketched so that they intersect the boundary flow lines at right angle and so that increment of DH on the phreatic line was approximately equal. The flow lines were sketched so that they inter-select. The equipotential lines at right angles and approximately formed square grid cells.
6. The flow line and equipotential line were then adjusted to achieve an even net.

Dam parameters

Tagwai dam project data	**Types Of Dam = Zoned Earth fill Dam**
Date Of Commencement – 20th September 1977.	Emergency spillway = 170m long with crest elevation of 258.3m
Date Of Completion = 1st November 1978.0	Active storage capacity = 26.5 x $10^6 m^3$.
Catchments Area = $110KM^2$.	Intake tower = Two No 24^N Dial steel pipe penstocks with guan and control
Average Annual Precipitation = 1270mm	Hydraulic height = 21m
Average Annul Run Off = 25 X 10^{-6} M^3	Maximum width of base = 150m
Crest Length = 1770m.	Dead storage capacity = 1.8 x $10^6 m^3$
Crest Level = 259m.	Surface Area of lake = 550 HA
Free Board = 4m	Total volume of earthworks. = $870{,}000m^3$
Maximum flood level = 257.5m O.D	Service spillway = 110 long. With crest elevation of 258.3m
Fuel supply Level = 256m O.D	
Crest Width = 10m	
Maximum structure high = 25m G.L	
Total storage capacity = 28 x 3 x $10^6 m^3$	

CHAPTER FOUR

DISCUSION OF RESULTS



igure 4.1 Graph of Percentage passing against particle size

om the graph above, we can be able to determine or classify the type of soil that are ere in the dam foundation. From the graph is it's noted that the soil is fine sand rticles.

e coefficient of permeability k is used to calculate the flow discharge in the dam. ing Darcy law where

$$= AV = AK \, {dh}/{ds} \qquad 1$$

Darcy law offers the single parameter K to account for both the characteristics of the medium and fluid. It has been found that K is a function of $\gamma\rho$ the unit weight of the fluid, μ, the coefficient of viscosity, and n, the porosity, as given by

$$K = c\frac{\gamma\rho n}{\mu} \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad 2$$

Where, c (dimensionally an area) typifies the characteristics of the medium independent of the fluid properties. The principal Advantage of equation (2) lies in its use when dealing with more than one fluid or with temperature variation. When employing a single relatively incompressible fluid subjected to small changes in temperature, such as in ground water – and seepage –related problems, it is more convenient to use K as a single parameter. Where K, is determine from table above

4.2.1 Discharge through the earth dam determination

The discharge through earth dam is usually computed from the flow net. However in this case, it can be obtained analytically; as explained below: according to Darcy law, the velocity

$$V = Ki \quad - \quad -- \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad -1$$

Where K is the coefficient of permeability and I is the hydraulic gradient. The seepage discharge per unit length of the dam is given by

$$q = VA = KiA \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad -2$$

Where A is the area of flow per unit length. For steady flow, the discharge through all vertical planes across the dam section will be the same. Let us consider the discharge through the vertical section PQ. Passing through the point P (x, y) Thus

$$q = KiA$$
$$q = K\left(\frac{dz}{dx}\right)(Z \times L) \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad 3$$

Where the hydraulic gradient (i) is equal $\frac{dy}{dx}$ (i.e. the tangent of the angle).

$$q = K \frac{d}{dz}\left(\sqrt{2xz + Z_0^2}\right)\left(\sqrt{2xz_0 + Z_0^2}\right)$$

$$or q = K\left(\frac{Zo}{\sqrt{2xzo + Z_0^2}}\right) \times C\sqrt{2xzo + Z_o^2}$$

$$or q = Kzo$$

Therefore the graph the value obtained.

$Zo = 9.078$m

K = 0.00000001 m/s from the permeability table for clay.

Q = 1 x10^{8}x 9.078 x1770

Q =1.6068 x 10^{-4} x 24 x 3600 x 365 x 1000

Q =5067204.48 liters/year

4.3 Graphical method

The values obtained from the graph are as follows. The distance from point B to point X is represented by L.

Where L = 7.50m

0.3 = 2.25m from point B to point A

NF = 4 Nd = 6

From Darcy law the discharge through the field is given by

$$\Delta q = KiA$$
$$or \Delta q = k\left(\frac{\Delta h}{l}\right) \times (b \times 1)$$
$$or \Delta q = k(\Delta h)\left(\frac{b}{l}\right) = k\left(\frac{h}{Nd}\right)\cdot\left(\frac{b}{l}\right)$$

Where Δh is the head drop through field, h is the total head causing flow and Nd is the number of equipotential lines.

Therefore the discharge through the entire dam is given by

$$q = \Sigma \Delta q = k\left(\frac{h}{Nd}\right)\left(\frac{b}{L}\right)NF \quad - \quad - \quad - \quad - \quad - \text{(a)}$$

Where Nf is the total members of flow channels.

For convenience, the flow fields are usually takes as square

Thus b = 1 and equation (a) becomes

Q= k x h (Nf/Nd)

Q = 1 x10^{-8} x21 x (4/6) x1770 x3600 x365 x 24 x1000

Q = 7818528.1104 liters/year

% of water loss = Q/Total volume of water x 100

% of water loss =7818528.1104/84 x10^{9} x 100

= 0.0093077% loss

CHAPTER FIVE

CONCLUSIONS AND RECCOMENDATION

.1 Conclusion

The seepage discharge through the dam is within the safe limits because the % of water loss per year is 0.0093077% is losses. Therefore seepage losses are minimal in Tagwai dam.

5.2 Recommendation

Under the present arrangement the dam is constructed for "Seepage control" rather than "Seepage prevention". Achieving prevention means the use of the normal previous foundation practice which includes the following.

- Construction of a positive cut off wall through the stream embedded alluvium to an impervious base, which is the impervious core material formation.
- A piezometer should be installing, to check or monitoring the aquifer pressure beneath the dam.
- Regular cleaning and the re-sloping of the drainage ditch in other to obtain free of water and stop the submergence of relief wells in affected areas during the rainy season.

References

Arora, K.R. (2002): Irrigation, Water and Water Resource Engineering. Fourth Edition ISBN: 81-8014-0075.

Bowles, J.E. (1984). Physical and Geotechnical Properties of soils Second edition. Mc Graw Hill Book Company. ISBN 0-07-006772-4.

Craig R.F. (1997), soil mechanics. Six editions, spon press.ISBN 0-419-22450-5

Casagrande, A, (1937). Seepage through dams, Journal of New England waters, 51,295-336

Cedergren, Harry R. (1977), Seepage Drainage, and flow nets, Willey. ISBN 0-471 14179-8

Chanson, H. (2009). Applied Hydrodynamics: An Introduction to ideal and real fluids flows.

De waist, R.J.M (1965): Geohydrology John Wiley and Sons, Inc.

Ferris, J.G, D.B Knowles, R.H.Stallman, (1962). Theory of Aquifer tests. Us Geological Survey water-supply paper 1536-E

Harr, M.E, (1962). Ground water and seepage, Dover. ISBN 0-486-66881-9.

Spangler, M.G. (1960): Engineering. The Haddon Craftsman Inc. (PP 143-145, PP 14)

APPENDIX

Table 4.1 Sieve analysis

Sieve size	**weight of sieve (g)**	**Weight of sieve + sample (g)**	**Retained sample (g)**	**Retained %**	**% Cumulative**	**% passing**
5.00	475.3	476.3	1.0	0.33	0.33	99.67
3.55	466.1	466.7	0.6	0.2	0.53	99.47
2.00	421.5	423.5	2.0	0.67	1.2	98.8
1.18	385.8	390.4	4.6	1.5	2.7	97.3
0.85	354.7	357.0	2.1	0.7	3.4	96.6
0.60	465.7	468.1	2.2	0.73	4.13	95.87
0.425	433.5	437.0	3.5	1.167	5.29	94.71
0.30	312.4	319.8	7.4	2.47	7.77	92.23
0.15	418.6	439.4	20.8	6.93	14.69	85.31
0.075	403.4	423.7	20.3	6.77	21.47	78.53
Pan	269.5	270.0	0.5	0.16	21.63	-

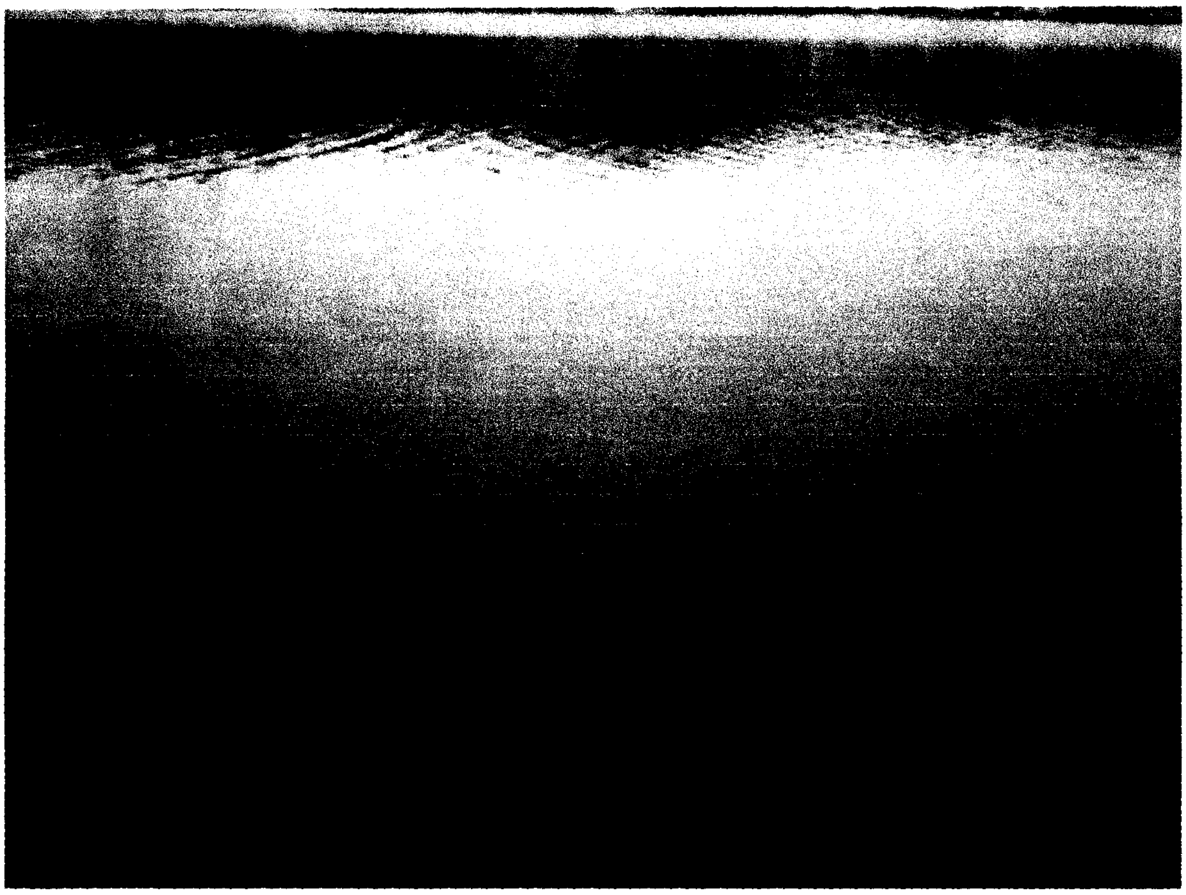
TABLE 4.2 Natural moisture content

	Sample A	
Can Number	**1D**	**4E**
Weight of can (g)	24.5	24.9
Weight of can + wet soil (g)	54.8	52.5
Weight of can + dry soil (g)	52.0	50.0
Moisture content (%)	10.2	9.96
Average Moisture content (%)	10	

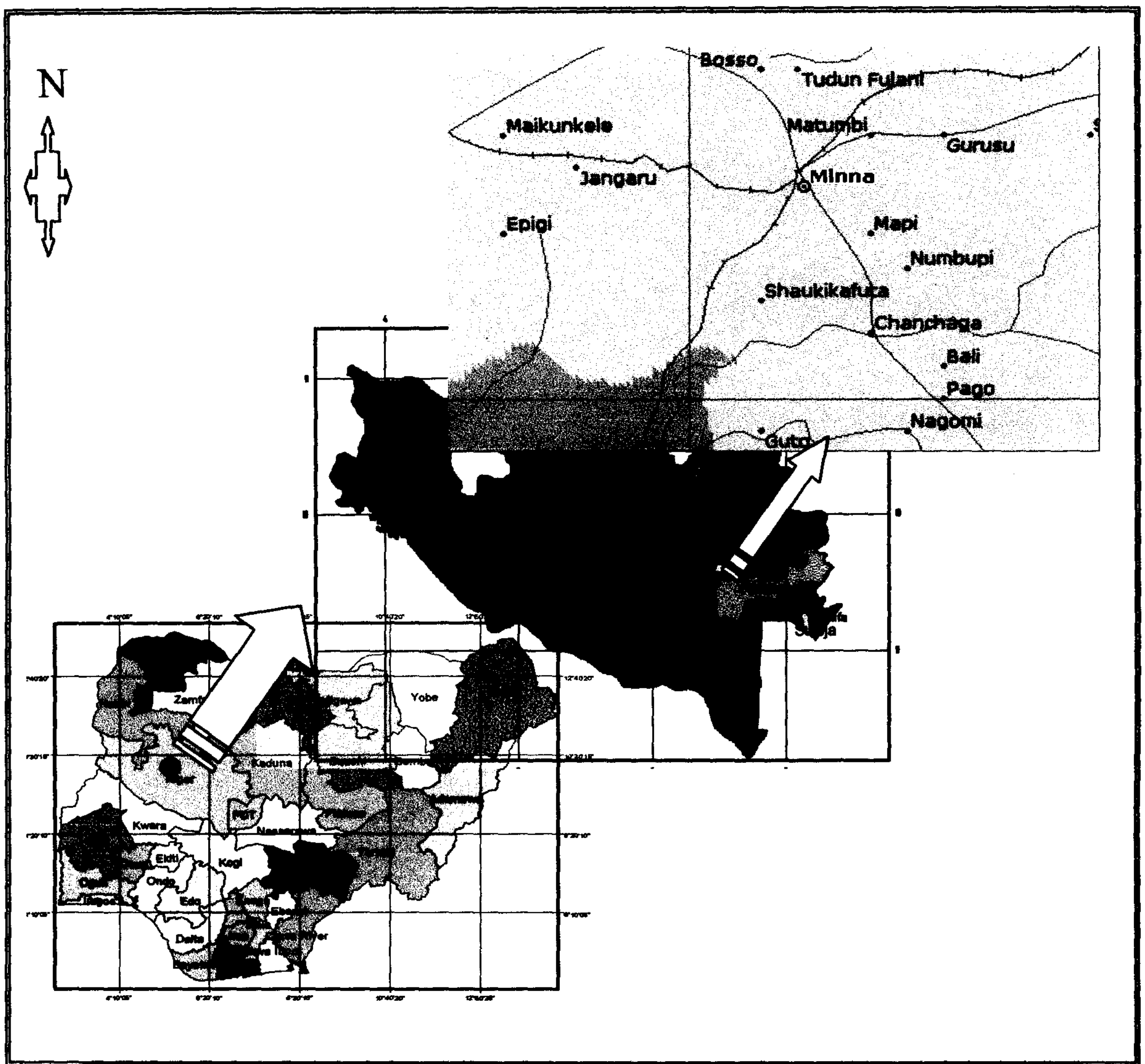
The aim of the above test is to determined moisture content of the soil, and the amount of water the soil content. From average moisture content which is 10%, this implies that the eepage through the dam is minimal.

able 4.3 Typical values of coefficient of permeability.

oil Types	Coefficient permeability K, cm/s
lean gravel	1.0 And greater.
lean sand (coarse)	1.0 -0.01
and (Mixture)	0.01-0.005
ine sand	0.05 -0.001
ilty sand	0.002 -0.00001
ilt	0.0005 – 0.00001
lay	0.000001 and smaller



Case study area : Tagwai dam



Map of study Area: minna, (9°37'- 9°79 and 6°16 - 6°65) Niger State , Nigeria

Figure 2 showing map of study area extracted from map of Nigeria.

Sources: Digitize 2007