STUDIES ON SEEPAGE IN CANAL NETWORK SYSTEM. A CASE STUDY OF CHANCHAGA IRRIGATION SCHEME (NIGER STATE)

BY

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A POST-GRADUATE DIPLOMA PROJECT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF POST GRADUATE DIPLOMA IN AGRICULTURAL ENGINEERING.

DECEMBER, 1999.

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APPROVAL

This project work (report) entitled **"STUDIES ON SEEPAGE IN CANAL NETWORK SYSTEM, A CASE STUDY OF CHANCHAGA IRRIGATION SCHEME** (NIGER STATE) by **NDAKO MOHAMMED** meet the regulations governing the award of post **GRADUATE DIPLOMA** IN AGRICULTURAL ENGINEERING OF Federal University of Technology Minna.

ENGR. NOSA A. EGHAREVBA NAME OF SUPERVISOR	.... SIGN / DATE.
DR. M.G. YISA NAME OF HEAD OF DEPT.	.... SIGN / DATE.

DECLARATION

This project is my original work conducted under the supervision of ENGR. NOSA A. EGHAREVBA. **To the best of my knowledge and belief the work has never been submitted to any University including Federal University of Technology Minna for the award of post-graduate Diploma or any degree.**

NDAKO MOHAMMED
PGD / AGRIC / 06 /97-98.

DEDICATION

I wish to dedicate this project to my late father Alh. Mohammed Djuru Kataeregi and my Mother madam Amina (Gbaka) Kataeregi.

ACKNOWLEDGEMENT

In the name of Allah the most beneficient the Merciful, I wish to express my profound gratitude to the following individuals and organisations who have contributed in one way or the other in making the write-up of my project a great success:-

Engr. Nosa A. Egharevba my able supervisor for his untiring assistance and guidance inspite of his numerous schedules

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Niger-State Ministry of Agriculture and Natural Resources and Ministry of Establishment and Training for approving and sponsoring my course, Department of Agric. Engineering Federal University of Technology Minna and others too numerous to mention.

ABSTRACT

project is to investigate seepage in canal network system in Chanchaga Irrigation me Niger State.

This is to quantify amount of water lost by seepage through the main canal and nels in Chanchaga irrigation scheme and it's effect on the canal the field and over all s yield.

Out of the methods that could be adopted for measurement of seepage losses, ling method was adopted by me to measure seepage losses in Chanchaga canal ork system because ponding method has been identified as the most accurate and ble for small canals.

Suggestions have been made on how to minimize seepage as it can not be pletely eliminated.

Field investigation showed that between 21% to 57.5% of water conveyed by canal / channels were lost through seepage which is causing serious water logging problems and utter destruction of good soils.

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTORY BACK GROUND

Chanchaga irrigation scheme is located between latitude 9^0 34'- 9^0 37'N and longitude $6^0\ 36^1 - 6^0\ 39^1$ E and situated at chanchaga village at the outskirt of Minna the capital of Niger State, this village is around 10km on Minna- Suleja trunk A road see fig 1.1

The idea of establishing this scheme came up in 1975 October, then the present Niger State was part of the defunct North – Western State, but started functioning in 1978.

The idea was conceived because series of survey and investigation report of the site indicated the suitability of the land for the establishment of an irrigation scheme. Source of water for this scheme is River- Chanchaga which is dependable. Also there are farmers who are interested in dry season farming.

The net scheme area covers a total of 10.5ha out of which wild flooding system is adopted for irrigating 8ha, while the remaining 2.5ha is irrigated by a system of network of canal and channels.

This canal conveys water required for irrigating 2.5ha of land.

1.2 SURFACE IRRIGATION SYSTEM

Irrigation is the artificial application of water to soil for the purpose of crop production. Irrigation water is supplied to supplement the water available from rain rainfall and contribution to soil moisture from ground water.

In many parts of the world the amount and timing of rainfall are not adequate to meet the moisture requirement of crops and therefore irrigation is essential to raise crops necessary to meet the need of food fibre.

In surface irrigation system, water is applied directly to the soil surface from canal / channel located at the upper reach of the field. Water could be distributed to the crops in border strips check basins or furrows but check basin irrigation was adopted in Chanchaga irrigation scheme.

Two general requirements of prime importance to obtain high efficiency in surface system of irrigation are properly constructed water distribution systems to provide adequate control of water to the fields and permit uniform distribution of water over the field.

1.3 SEEPAGE IN FARM CANALS

Seepage in canal is the loss of water in canal which depends on the length of the water –course, it's wetted perimeter and the intrinsic permeability of the strata through which the canal passes or materials (soils) used in construction of the canal.

Seepage could be designated in m^3 / hr per m^2 of the wetted area of the canal / channel.

Uncontrolled seepage results in loss of water through the canal and loss in strength of soil and finally failure of the canal. In controlling seepage, care should be taken to ensure that correction at one point does not aggravate conditions at the other.

Unlined earth canals like that of Chanchaga Irrigation Scheme are frequently used in water conveyance on the irrigation schemes. Earth canals are easily accepted by farmers, and can be built and maintained by unskilled persons and with banks strong enough to carry the required flow of water safely at non-erosive velocity. Side slopes should be flat enough so that the banks will neither cave in nor slide when they are saturated with water.

Irrigation canals should not have side slopes steeper than $1^{1/2}$ horizontal to 1 vertical. A canal should not slope steeper than 1½ horizontal to 1 vertical. Normally, a canal should slope 0.1 percent as it will silt up if the slope is less than 0.05percent (Micheal 1978).

Seepage of water from irrigation canal is a serious problem. Not only is water lost, but also drainage problems are aggravated on adjacent or lower lands. Occasionally, water that seeps out of a canal re-enters the river in the valley where it can be re-diverted, or enters an aquifer where it can be re-used. It is more serious economic loss when the water seepage losses are not recoverable.

Also economic and legal liabilities may result from water seepage from upper canal causing drainage problems on lower lying lands, these may be complex.

Usually, the farmers at the head of the main-canal gets nearly the full supply of water due to less seepage, while water available to the farmer at the tail end is comparatively much less.

Beside seepage from a canal network system, there is also evaporation from open water surface, these two losses are addressed as Transmission loss. Evaporation in canals from literature accounts for a small quantity of the losses and therefore negligible.

1.4. PROJECT JUSTIFICATION

In particular, the project is aimed at

(a) quantification of the irrigation water loss through seepage in the unlined canal net work.

(b) Highlighting some recommendations that could correct this seepage problems.

.5. PROJECT OBJECTIVES

The main objectives of this project include among others:

(a) to increase food production for growing population of Minna and beyond, and

(b) to enhance economic status of participating dry season farmers from Chanchaga and it's environs.

CHAPTER TWO

LITERATURE REVIEW

2. 1 INTRODUCTION

Amount of seepage losses in Irrigation canal network system depends on:-

(i) the nature and salinity of the soil
(ii) depth, turbidity and temperature of water
(iii) age and shape of canal section and
(iv) position of ground water level.

Various methods used in measuring seepage from canals include the followings (Hansen, 1962)

(i) Inflow – out flow method,
(ii) Ponding method
(iii) Use of seepage meters,
(iv) Laboratory tests of permeability of soils, electrical resistance and
(v) Tracing of natural and radio – active salts.

The method best suited to the canal will depend on the depth and velocity of flow, the material in the canal bed and rate of seepage.

But, the three most commonly used methods are:- the inflow-out flow, ponding and seepage meter methods.

2.2 INFLOW-OUT FLOW METHOD

This consists of measuring the flow into and the flow from selected section of canal. The accuracy of this method, increases with difference between the quantity of in flow out flow rates. Water level should be held constant during the measurement and allowance be made for rainfall and evaporation.

2.3 PONDING METHOD

Ponding method consists of creating a temporary pond in selected reaches of the canal by constructing water-tight temporary barriers like wall, bund or steel plates at the commencement and at the end of the test reach. (RAJAN, 1982).

The pond is filled with water and the rate of fall of water surface on account of seepage is measured per hour. The seepage rate in the test reach is computed for different depth conditions. It is apparent that all inlets and outlets of the canal test reach are closed completely during the time of observations.

However, simultaneous measurements of leakage if any, are to be made.

This method requires closure of canal during the test period and construction of temporary walls to isolate the rest reaches.

The determination of seepage by ponding method provides an accurate means of measuring seepage losses and is especially suitable when the loss to be estimated is small. See fig. 2.1.

2.4 USE OF SEEPAGE METERS

These are used to obtain measurements of seepage from relatively small areas of canal surface. Measurements can be taken without disturbing the flow in the canal unless velocity is excessive. Seepage meters generally consists of a cylinder with dome or cone on the top to allow for trapped air to be removed from the system through a valve attached to the top of the cone. The cylinder is pressed gently into the soil and the unit filled with water and placed beneath the water surface. Seepage within the cylinder causes a corresponding reduction in water content in the plastic bag. The loss of weight of the bag indicates the rate of seepage through the cylinder surface. (Hansen, 1962).

But extensive studies indicate that several factors contribute to error in seepage meter, so that these meters give only an indication of order of magnitude of seepage rather than absolute rates of seepage. The surface is disturbed by installing the meter and the area under test is small and may not be representative of the canal section. And to obtain results indicative of actual seepage, several readings are necessary with representative readings taken on these sides as well as on the bottom of the canal.

2.5 CANAL LINING

Seepage losses in hill channels were found to vary from 15 percent to 90 per cent; hence the need to line the canal/channels (Chaturvedi, 1982).

Selection of possible lining method was based on a careful analysis of possible lining methods, availability and labour cost, mechanical equipment and construction materials, transport facilities, anticipated irrigation method and canal operation, traditional lining techniques, availability of skilled and unskilled labour.

The types of lining generally adopted include the followings (Chaturvedi, 1982).

(i) dry rough stone lining with large projections of the order of 20 to 40cm,
(ii) masonry lining and slate lining,
(iii) earth and soil cement lining,
(iv) soil, paddy husk, cow-dung and sand,
(v) asphalt lining and
(vi) concrete lining.

Out of all the enumerated methods of lining, concrete lining was found to have better overall performance. In construction, particular care should be taken regarding thorough compaction of the sub-grade on which the lining was to be laid.

But, the quantum of seepage has to be estimated accurately to work out the benefit cost ratio to be derived from such an exercise, then decision on whether to line canal/channels is taken. (Rajan,1982).

CHAPTER THREE

MATERIALS AND METHODS

3.1 METHOD ADOPTED

The experiment was conducted at Chanchaga irrigation Scheme on the 9^{th}, 10^{th} and 11^{th} day of February 1999.

The method adopted in determining seepage in the canal network system of Chanchaga Irrigation Scheme was the **PONDING** method.

This method was adopted because of all the methods to determine seepage in canal network system, this method from literature has been the most accurate and dependable method. Also this method is best adapted to localities where irrigation is seasonal in nature like Chanchaga Irrigation Scheme.

3.2 EXPERIMENTAL DESIGN AND PROCEDURE

3.2.1. SEEPAGE MEASUREMENT

First and foremost, physical dimensions of the selected reaches of canal and Field channels 1, 2 and 3 were measured by means of measuring Tape, ruler, leveling staff and instrument to provide data necessary to compute the seepage loss. The length of pond was limited to ensure that upstream and down stream depths do not differ appreciably. Also to obtain satisfactory results the ponded reach was selected so as to avoid inflow or outflow which cannot be accurately measured.

Three ponded reaches were selected each for canal and channels. First reach was at the beginning, second reach was at the middle and the third reach was at the end. The length of each reach was 20m (see fig. 3.1-3.2).

After this, water tight temporary barriers were created at the commencement and at the end of the ponded reach using steel plates 4mm thick, 0.6m. wide and 0.35m high. The seepage rate through the sides and bottom of canal/channels were calculated by ponding method as indicated in Table 4.1. The following equation was used for the computation of seepage rate: (Ahmed 1984).

$$S=\frac{W(d_1-d_2)\,L.24}{P.\,L.\,t.} \qquad \text{------ } 3.1$$

S=Seepage rate in $m^3/m^2/day$

W=Average width of water surface in meters

d_1=Actual depth of water at the beginning of measurement in meters

d_2=Depth of water in m. after time 't'

L=Length of canal/channel in m

P=Average Wetted perimeter in m

t= Time interval between d_1, and d_2 in hr.
The canal/channels were filled with water to certain level by means of pumping through pipes. The pump used is MARITZA – 50A this pump has the following characteristics:-

(i) Discharge - 55 litres/second
(ii) Total Dynamic head (TDH) - 50m
(iii) Horse Power (H.P) - 36
(iv) Revolutions per minute (RPM) 1800 and
(v) Area of Coverage/day - 12ha.

But before pumping commenced, all possible points of leakages within the canal/channels were properly closed to ensure correct determination of seepage.
At first, the initial depth d_1 was recorded and after an hour interval t, the final depth d_2 was recorded, the difference between the two gives the fall in water level which was mainly due to seepage through the bottom and sides of the canal/channels, (I earlier indicated: - in Chapter One, that other losses from evaporation etc accounts for a small quantity of the losses and therefore negligible). From this, drop in volume of water in canal/channels could be calculated and also subsequent percentage of drop in volume as shown in Table 4.2

3.3 PHYSICAL CHARACTERISTICS OF SOIL

Soil samples were taken at four different points, i.e. at areas commanded by main-canal, field – channels 1,2 and 3 using soil auger up to depth of 60cm.

The following characteristics were determined for the soil of the project area:-

(i) Texture
(ii) Bulk – Density
(iii) Soil moisture content
(iv) Field – Capacity

3.3.1 SOIL – TEXTURE

This is defined by the particle size distribution which ranges from clay particles of less than 0.002mm to stones of up to 50mm in diameter (Brady, 1974).

Soil texture was determined when the particles were separated by Bouycous Hydrometer Method. This method involved the breaking of soil aggregates into primary particles in order to measure the amount of silt, sand and clay. This was done by using a dispersing agent (a sodium salt called Hexameta – Phosphate) and mixing the suspension with high speed stirrer. Normally, 50gm was taken and 100 of hexameta – phosphate was added. Table 4.3 shows the result.

3.3.2 BULK – DENSITY

This is the mass (weight) of a unit volume of dry soil, given in grammes/cubic centimeters. Bulk density was determined by first taking soil samples and weighing them using cylinders of convenient sizes under moist condition from the field. The samples were then oven-dried at oven temperature of 105^{0}C until all the moisture is driven-off and the samples were then weighed again.
The weight of the soil in grammes divided by the volume of the soil in cubic centimeters is the bulk-density. The values obtained are outlined in Table 4.4.

3.3.3 SOIL – MOISTURE CONTENT

This is the amount of water in a given amount of soil. Soil moisture on weight basis is based on the dry weight of the sample.

$$\text{Soil Moisture Content Percent By weight} = \frac{\text{Weight of Moist Sample} - \text{Weight of Oven Dry Sample}}{\text{Weight of Oven Dry sample}} \times 100 \quad \ldots\ldots\ldots 3.2$$

Gravimetric method was adopted in measuring soil moisture content. This method involves taking soil samples of known weight with a soil auger. The samples were taken from successive depths of 0-15cm, 15-30cm,30-45cm and 45-60cm, at four different locations i.e. areas commanded by main canal, field-channels 1, 2 and 3.

The soil samples were weighed and dried in an oven at 105^{0}C for about 24 hours until all moisture is driven off. After removing from oven, they are cooled slowly to room temperature and weighed again. The difference in weight is the amount of moisture in the soil; and soil moisture content percentage by weight is calculated using the above equation (Equation 3.2). The results are shown on Table 4.5.

3.3.4 FIELD – CAPACITY

The field capacity of soil is the moisture content after drainage of gravitational water has become very slow and the moisture content has become relatively stable. This situation usually exist one to three days after the soil has been thoroughly wetted. At field – capacity, the large soil pores are filled with air, and the micro-pores are filled with water. Field capacity is the upper limit~~ed~~ of available moisture range in soil moisture.

Field-capacity was determined by ponding water on the soil surface in an area of 4m^2 and permitting it to drain for three days. Three days after the soil was thoroughly wetted, soil samples were collected with an auger from different soil depths at uniform intervals as earlier indicated. The moisture content was determined by the gravimetric method earlier described. The field capacity values are shown on table 4.6

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 SEEPAGE RATE

Table 4.1 shows mean seepage rate for canal/channels 1, 2 and 3. The parameters of the cross-section of canal and channels were measured out and results are as follows:-

(a) For main canal
Depth - 0.45m
Side slope - $1^{1/2}$ Horizontal to 1 vertical
Bed width - 0.42m.

(b) For Field-channels
Depth - 0.40m
Side slope - $1^{1/2}$ Horizontal to 1 vertical
Bed width - 0.35m.

Table 4.2 shows percentage of seepage per hour for main-canal/field channels. From results shown on Table 4.1, rate of seepage in the main-canal is much less than that of the field channels. With this result, this experiment could be concluded to be okay. This is because, from literature, canals are expected to have lower seepage rate. (Rajan, 1982).

And from results shown on table 4.2, mean percentage of seepage in canal and field channels has fallen between the ranges of 22.54% (for main canal) and 57.26% (For field-channels). This result also could be concluded as being okay, because from literature, it was discovered that seepage losses in channels were found to vary from 15% to 90%.

In view of results obtained, the need to reduce seepage of canal and channels by properly lining them cannot be over-emphasised. Cost of properly lining the whole length of the main-canal is N89,200 while that of the field channels is N92,000 based on an estimate of N4,000.00 per cubic metre of mass concrete. This then gives a total cost of N181,200.00 only. Total length of main-canal is 312.5m, while that of field-channels is 319.4m, and assuming lining thickness of 0.035m.

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SOIL TEXTURE

From Table 4.3, it could be concluded that virtually, the soil type of the project area is silty clay loam, this is because all the three fractions of the soil i.e. sand, clay and silt, occur in sizeable proportions.

BULK – DENSITY

From results obtained, as indicated on Table 4.4. mean Bulk-density is 1.52 g/cm^3, with this, it could therefore be concluded that the result is okay, this is because, if bulk densities of clay and sand are $1.0 g/cm^3$ and $1.8 g/cm^3$ respectively, then that of silty clay loam should fall within the two ranges as indicated above.

SOIL MOISTURE CONTENT

From results obtained as indicated on table 4.5, soil moisture content increases with depth. For example, for 15-30cm, the moisture content is 0.65%, and for 30-45cm, the value is 6.89% and finally for 45-60cm depth the moisture content increased to 8.21%.

FIELD - CAPACITY

Table 4.6 shows results obtained. This result shows that Field-capacity is generally lower than the moisture content.

And for sandy soils, field – capacity from literature exceeds the moisture content, but is generally lower in silty clay loam soils, it could therefore be concluded that the experiment is correct.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

To achieve optimum usage of Irrigation water being conveyed by the canal/channels, every effort should be geared towards prevention of seepage of this Irrigation water in canal network - system of Chanchaga Irrigation Scheme.

It should be realised that a lot of money is expended in purchasing, facilities; such as pumps, pipes and their accessories that facilitate pumping and conveyance of Irrigation water to the canal/channels, therefore, the need to prevent seepage cannot be over-emphasised.

As pump(s) are used in pumping this Irrigation water to the canal/channels, and pumps generate that energy - required for pumping water by the use of fuel/lubricant; and with the current hike in the price of these commodities, if water is allowed to waste by means of seepage, a lot of money shall be expended over and above what is actually required to fuel/lubricate the pumps, therefore every effort should be made to prevent seepage.

5.2 RECOMMENDATION

In view of results obtained, I wish to recommend thus:-

(i) that materials for canal/channel construction should be ideally be non-expensive, be relatively impervious and relatively erosion resistant, this could be obtained by mixing small amount of clay with sand in construction or by injection of clay or cement into voids of soils.

(ii) that in construction of canal/channels, soil should be compacted well in order to reduce seepage loses and also add to the stability of the soil and thus reduce erosion of the bed and banks of the canal/channels.

But when adequate funds are made available, canal/channels should be properly lined. Lining of irrigation canal could prevent seepage and may result in satisfactory lowering of the water table in this area, thus removing the need for drainage as water – logging caused by seepage is eliminated.

Concrete lining should be used to a greater extent as it gives long-service with minimum repair and maintenance cost.

A mixture of one part cement, three of sand and four or five of graded gravel from 1 to 3cm size should be adopted as it makes a strong and durable lining. A water – cement ratio of 25 litres per bag of cement should be adopted as it gives good result. The lining should not be less than 3.5cm thick.

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APPENDIX A

Equation $S = \frac{W(d_1 - d_2) L. 24}{P. L. t}$ - 3.1

Was applied in the calculation of seepage rate(s) for canal/channels and the unit is $m^3/m^2/day$.
Sample calculation of seepage rate for main canal (fig.3. 1) :-

For the First Reach
Initial depth of water $d_1 = 0.28m$
Depth of water after one hour $d_2 = 0.238m$
Initial width of water surface $W_1 = 1.26m$
Width of water surface after one hour $W_2 = 1.134m$

$\therefore$ Average width of water surface $W = \frac{W_1 + W_2}{2} = 1.197m.$

Initial wetted perimeter $P_1 = 1.43m$
Wetted perimeter after one hour $P_2 = 1.278m$

$\therefore$ Average wetted perimeter $P = \frac{P_1 + P_2}{2} = 1.1354m.$

Length of Reach L = 20m.
Time interval between d_1 and d_2, t = 1 hr.

$\therefore$ Seepage rate (s) of the First Reach of the main-canal was calculated by transposing all values calculated above into equation – 3.1

$$S = \frac{1.197\ (0.28\ -\ 0.238)\ 20 \times 24}{1.354 \times 20 \times 1} = 0.891 m^3/m^2/day.$$

Then the value obtained is divided by 24 to get seepage rate per hour

$$= \frac{0.891}{24} = 0.03713 m^3/m^2/hr = 0.037 m^3/m^2/hr$$

This value is shown on Table 4.1, the other values were calculated using the same method.

TABLE 4.1 MEAN SEEPAGE OF CANAL NETWORK SYSTEM OF CHANCHAGA IRRIGATION SCHEME.

DESCRIPTION	SEEPAGE AT VARIOUS REACHES M3 /M2 /hr			TOTAL	MEAN M^3 / M^2 / hr
	1st REACH	2nd REACH	3rd REACH		
Main-canal	0.037	0.039	0.038	0.114	0.038
Field-canal 1	0.071	0.06	0.071	0.202	0.067
Field-canal 2	0.09	0.084	0.090	0.264	0.088
Field-canal 3	0.096	0.099	0.097	0.292	0.097

Mean Average seepage rate for the canal Network system of Chanchaga irrigation scheme is $0.073m^3/m^2/hr$

TABLE 4.2 PERCENTAGE OF SEEPAGE IN MAIN-CANAL AND CHANNELS AT CHANCHAGA IRRIGATION SCHEME

DESCRIPTION	SEEPAGE PERCENTAGE % AT VARIOUS REACHES.			TOTAL %	MEAN %
	1ST REACH	2ND REACH	3RD REACH		
Main-canal	21.40	23.32	22.90	67.62	22.54
Field-channel 1	51.15	43.50	50.80	145.45	48.48
Field-channel 2	57.50	53.00	57.90	168.40	56.13
Field-channel 3	57. 48	57.70	56.60	171.78	57.26

Mean percentage of seepage in canal Network system of chanchaga irrigation scheme is 46.10%

TABLE 4.3 SOIL- TEXTURE.

SAMPLES FROM AREA COMMANDED BY	DEPTH OF SAMPLE(CM)	%SAND	% SILT	% CLAY	REMARKS
Main-canal	15	16	60	24	Silt-Loam
Field-channel 1	15	14	44	42	Silt-Loam
Field-channel 2	15	15	46	39	Silty-Clay
Field-channel 3	15	20	48	32	Silty-Clay Loam
Main-canal	30	16	35	49	Clay
Field-channel 1	30	14	41	45	Silly-Clay
Field-channel 2	30	12	38	50	Silly-Clay
Field-channel 3	30	15	38	47	Silly-Clay
Main-canal	45	12	42	46	Silty-Clay
Field-channel 1	45	13	37	50	Silty-Clay Loam
Field-channel 2	45	12	45	41	Silty-Clay Loam
Field-channel 3	45	13	26	61	Clay
Main-canal	60	10	30	60	Clay
Field-channel 1	60	11	33	56	Clay
Field-channel 2	60	12	30	58	Clay
Field-channel 3	60	9	36	55	Clay

TABLE 4.4 BULK-DENSITY

SAMPLE NO	DEPTH OF SAMPLE(CM)	WEIGHT OF CAN PLUS DRY SOIL (g)	WEIGHT OF CAN (g)	WEIGHT OF DRY SOIL AT 105^0c (g)	VOLUME OF CORE CYLINDER (CM^3)	DENSITY(g/ Cm^3)	MEAN (g/cm3)	S.D
1	15	277.2	50.0	227.2	160.0	1.42		
2	15	274.0	50.0	224.0	160.0	1.40	1.43	0.024
3	15	282.0	50.0	232.0	160.0	1.45		
4	15	283.6	50.0	233.6	160.0	1.46		
5	30	293.2	50.0	243.2	160.0	1.52		
6	30	296.4	50.0	246.4	160.0	1.54	1.56	0.030
7	30	301.2	50.0	251.2	160.0	1.57		
8	30	306.0	50.0	256.0	160.0	1.60		
9	45	293.2	50.0	243.2	160.0	1.52		
10	45	299.6	50.0	249.6	160.0	1.56	1.53	0.022
11	45	293.2	50.0	243.2	160.0	1.52		
12	45	290.0	50.0	240.0	160.0	1.50		
13	60	302.8	50.0	252.8	160.0	1.58		
14	60	301.2	50.0	251.2	160.0	1.57		
15	60	306.0	50.0	256.0	160.0	1.60	1.58	0.015
16	60	299.6	50.0	249.6	160.0	1.56		

Mean Bulk-Density of the soil of the project area =1.52g/cm^3

TABLE 4.5 SOIL MOISTURE CONTENT

SAMPLE NO	DEPTH OF SAMPLE (CM)	WEIGHT OF MOIST SOIL SAMPLE (gm)	OVEN DRY WEIGHT OF SOIL SAMPLE (gm)	SOIL MOISTURE CONTENT IN PERCENTAGE %	MEAN	STANDARD DEVIATION (S.D)
1	15	34.60	26.82	29.00		
2	15	36.71	28.38	29.35	28.95	0.84
3	15	35.98	28.20	27.59		
4	15	36.01	27.73	29.86		
5	30	36.28	27.95	29.80		
6	30	36.31	28.68	26.60	30.27	2.89
7	30	35.89	27.61	29.99		
8	30	32.34	24.01	34.69		
9	45	30.95	20.62	36.82		
10	45	29.01	20.68	40.26		
11	45	29.00	21.99	31.88	36.51	2.99
12	45	28.77	20.99	37.07		
13	60	28.69	21.68	32.33		
14	60	27.98	20.20	38.51		
15	60	26.89	19.88	35.26	37.16	3.80
16	60	26.07	18.29	42.54		

Mean soil moisture content in percentage = 33.22%

TABLE 4.6 FIELD - CAPACITY

SAMPLE NO	DEPTH OF SAMPLE (CM)	WEIGHT OF SAMPLE AT FIELD-CAPACITY (g)	OVEN DRY WEIGHT SAMPLE (g)	PERCENTAGE WATER AT FIELD-CAPACITY	MEAN	S.D
1	15	40.00	34.00	17.65		
2	15	40.50	34.50	17.39	16.99	1.82
3	15	40.58	34.21	18.62		
4	15	40.00	35.00	14.29		
5	30	38.00	32.10	18.38		
6	30	35.00	30.50	14.75	16.52	1.33
7	30	34.50	29.50	16.95		
8	30	35.50	30.60	16.01		
9	45	35.50	30.60	16.34		
10	45	35.50	30.70	16.29		
11	45	33.09	28.65	15.50	15.59	0.86
12	45	30.37	26.59	14.22		
13	60	35.00	30.50	14.75		
14	60	34.50	29.50	16.95		
15	60	30.27	26.49	14.27	15.03	1.13
16	60	30.47	26.69	14.16		

MEASUREMENT OF RATE OF FALL OF WATER-
SURFACE IN CHANCHAGA CANAL NETWORK SYSTEM
WHICH IS DUE TO SEEPAGE.

FIG 2.1

CROSS-SECTION OF MAIN CANAL.

SCALE:-
1CM - 0.12M

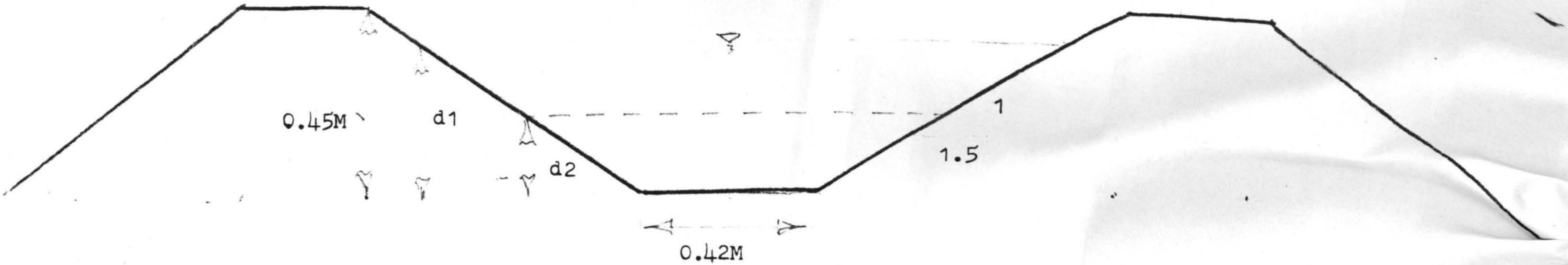
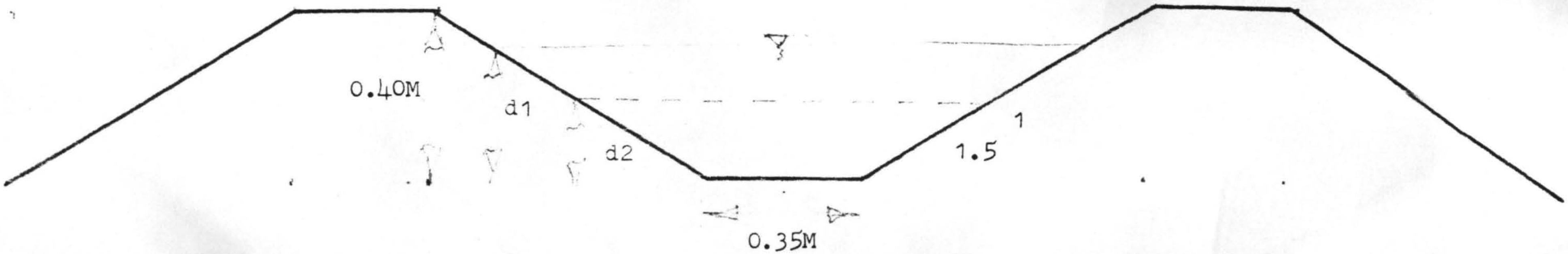


FIG 3.1

d_1 = Initial depth of water in metre

d_2 = depth of water after one hour.

CROSS-SECTION OF FIELD-CHANNEL



FIG, 3.2