Design And Management Of Mettur Dam By Predicting Seepage Losses Using Remote Sensing

T.Subramani[1], K.Ashok Kumar[2], A.Ganesan [3], P.Senthil[4], G.Gunasekar[5]

[1]Professor & Dean, Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions University, Salem, India

[2,3,4,5]UG Student, , Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions University, Salem, India

ABSTRACT

In dam safety assessment, it is customary to focus on stability analysis, and the safety factor is regarded as an assessment index that cannot correctly reflect the effect of multi-factors and variable uncertainty. The factors that induce dam breaks are complex and uncertain; however, three primary ones can be identified: hydrological factors, seepage and bank slope instability. In this paper, the risk probability and the dam break threshold value for each factor individually, as well as coupled factors, are studied. The threshold value is acquired using the relationship formula between risk probability and dam type. In our project we are discussing about the details of Mettur dam in Tamilnadu. In this study the seepage losses calculating methods and prevention techniques also adopted.

Keywords: Design, Management, Mettur Dam, Predicting Seepage Losses, Remote Sensing

1.INTRODUCTION

The term 'Seepage' as it applies to the area of reclamation can be defined as ' The slow movement or percolation of water through soil or rock. Movement of water through soil without formation of definite channels. The movement of water into and through the soil from unlined canals, ditches, and water storage facilities. The slow movement or percolation of water through small cracks, pores, interstices, etc., from an embankment, abutment, or foundation'. The term 'Seepage' as it applies to the area of water can be defined as

(1) The slow movement of water through small cracks, pores, Interstices, etc., of a material into or out of a body of surface or subsurface water.
(2) The loss of water by infiltration into the soil from a canal, ditches, laterals, watercourse, reservoir, storage facilities, or other body of water, or from a field'.

The term 'Seepage' as it applies to the area of the weather can be defined as ' In hydrologic terms, the interstitial movement of water that may take place through a dam, its foundation, or abutments'. All our developmental plans have given high priority to water resources projects involving construction of dams and creation of reservoirs for flood control, irrigation, hydropower etc. During the past, many major and medium river valley projects comprising large reservoirs have been constructed. As the above storages are subject to silting, sedimentation of reservoirs is a matter of vital concern to all water resources development projects. Silting not only occurs in the dead storage but also encroaches into the live storage capacity which impairs the intended benefits for the reservoirs. Water storage capacity of reservoirs is reduced by the accumulating sediments. The long term efficiency of reservoirs also gets reduced considerably. Therefore, the problem of sedimentation needs careful consideration. Soil erosion, its transportation and subsequent deposition in reservoirs is a universal phenomenon. Uncontrolled deforestation, forest-fires, over grazing, improper methods of tillage, unwise agriculture practices and other activities are mainly responsible for accelerated soil erosion. All eroded material does not get into a stream. Some particles travel for a short distance and get deposited before reaching a stream for want of sufficient velocity of water. Some may travel into the river system and get lodged in the vegetation on the banks. Some others may be carried downstream only to be deposited in the plains and finally only a portion of eroded particles enters the reservoir. Thus at a given control point on a river all the sediment produced by the upstream watershed does not get delivered. In a cascade system of reservoirs, upstream reservoirs intercept a part of the transported material and sediment inflow into the downstream reservoir reduces.

The Mettur Dam is one of the largest dams in India. Built in 1934, it was constructed in a gorge, where the Kaveri River enters the plains. It provides irrigation facilities to parts of Salem, the length of Erode, Namakkal, Karur, Tiruchirappali and Thanjavur district for 271,000 acres (110,000 ha) of farm land. The total length of the dam is 1,700 metres (5,600 ft). The dam creates Stanley Reservoir. The Mettur Hydro Electrical power project is also quite large. The dam, the park, the major hydroelectric power stations, and hills on all sides make Mettur a tourist attraction. Upstream from the dam is Hogenakal Falls. The maximum level of the dam is 120 ft (37 m) and the maximum capacity is 93.47 tmc ft.

Its capacity of 93.4 billion cubic feet (2.64 km^3) is nearly twice that of its Karnataka counterpart of KRS; the dam is revered as the life and livelihood-giving asset of Tamil Nadu. It was built in-line with KRS Dam, which was designed by Sir M Vishveswariah in 1911 and completed in 1917 near Mysore.

2.STUDY AREA

Tamil Nadu is the southern most state of India and Salem district lies in the interior of Tamil Nadu between latitudes 110 00' and 12° 00'N and the t-'°141 longitudes 77°40' and 78° 50'E (Referrtoposheetst58 Ill, 2, 3, 4, 5, 6, 7 and 8 and 58 E/13, 14, 15 and 16 of scale 1:50,000 published by Survey of India). The Salem district is marked by isolated hills covering an area of 8643 sq.km. Rivers Cauvery, Sarabanga, Thirumanimuttar, Sweta and Vasista are the important rivers draining the district. The Cauvery is the only perennial river and Sarabanga and Thirumanimuttar are tributaries of the Cauvery. Several isolated hillocks like Godumalai, Nagaramalai, Kanjamalai, Bodamalai, Nainarmalai and Suriyamalai are present in the study area. The southern part of Salem district is generally a plain area with mean altitude of about 200 m above mean sea level (ms1). In the northern part of the district, Shevaroy hills has a maximum height of 1640 m msl. (Figure.1 & Figure.2)

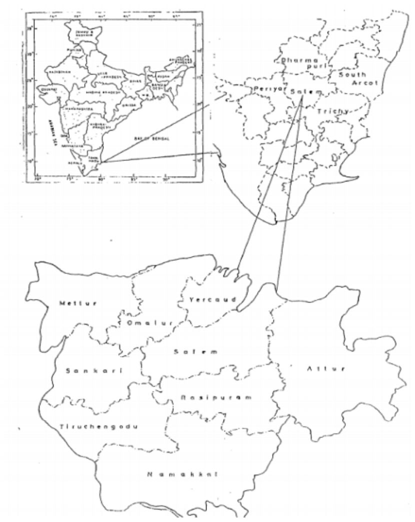

Figure. 1 Salem Location

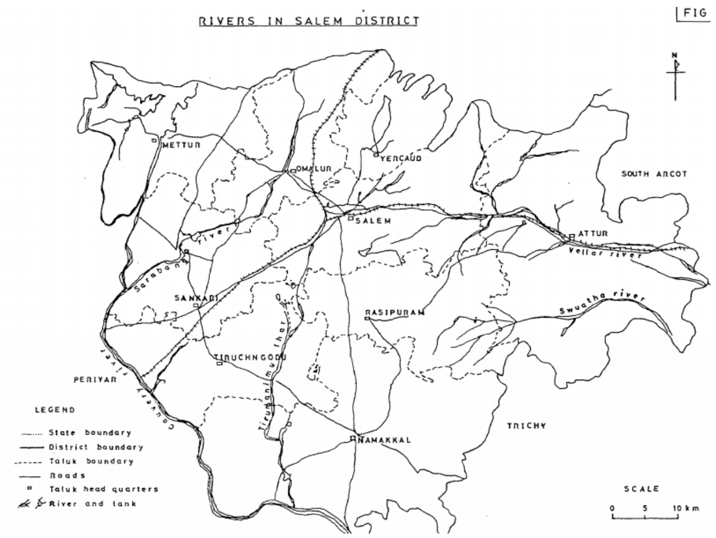

Figure. 2 Rivers In Salem District

2.1 INTRODUCTION TO THE STUDY AREA, METTUR

Introduction The author hails from Mettur town. During his reconnaissance survey in the nearby hills, he noticed excellent outcrops showing charnockite-gneiss relationship set in a granulite terrane. The author makes an attempt to give a detailed account on the geology of the area in and around Mettur. It is almost a virgin area. Though carbonate rocks have been reported no detailed work has been reported on the geology in and around Mettur. This area is located along the fault zone reported. Mettur town is located on the north-eastern corner of Salem district. In Mettur, a dam running to 1.5 Km. in length is one of the best constructed masonary dams of South India.(Figure.3). The river Cauvery flows through Mettur and the Mettur reservoir can hold 95,660 million cubic feet water upto a maximum level of 120 feet. The entire region in and around Mettur is comprised of highly metamorphosed rocks. Structural patterns in the high grade terrain of Tamil Nadu has been worked out by many geologists and only recently the detailed geological mapping has brought out vast areas occupied by highly deformed charnockites and high grade gneisses. In such areas, charnockite is intensively co-folded with supracrustal group of rocks represented by khondalite, quartz magnetite rock, pyroxene granulites and layered ultramafics. Further these areas have undergone five phases of deformation, five generation of basic dyke activities and four phases or migmatization and two periods of metallogeny.

Figure. 3 Mettur Dam

In recent years, several workers has studied the widespread retrogression of charnockites to hornblende biotite gneiss along the shear zones The detailed study carried out by the author involved three stages. i. -.10reparation'of Base map . Geological and structural mapping Laboratory studies. 1.2.1 Preparation of base map The Base map of the study are Phas been prepared by using the topo sheet 58 E/13 (1:50000 scale) published by the Geological Survey of India in the year 1972. This map was used by the author to locate the various villages, dam site, river courses, hills, hillocks and to find way to reach the delecate areas. 1.2.2 Geological and Structural Mapping During the months of February, March, May and June 1996, the author carried out a detailed field work. Typical rock types, important structural features and geomor phological characters has been identified and some of them photographed.

3.SEEPAGE LOSSES

The seepage loss results not only in depleted freshwater resources but also causes water logging, salinization, and ground-water contamination. Canals in alluvium are lined in general and reduce the seepage in particular. Seepage from a lined canal occurs at reduced rate. The perfect lining would prevent all the seepage loss, but a canal lining deteriorates with time. A well-maintained canal with a 99% perfect lining reduces seepage about 30–40%; seepage from a canal cannot be controlled completely. Significant seepage losses do occur from a canal even if it is lined. Therefore, a canal cross section should be designed in such a shape and with dimensions that minimize the seepage loss.

This paper addresses the design of a minimum seepage section. The seepage loss from canals is governed by hydraulic conductivity of the sub soils, canal geometry, hydraulic gradient between the canal and the aquifer underneath, and initial and boundary conditions. The seepage loss from a canal in an unconfined flow condition is finite and maximum when the water table lies at a very large depth. Canal seepage has been estimated for different sets of specific conditions .However, the methods adopted by various investigators are applicable to known canal steady-state seepage from a trapezoidal canal in a homogeneous isotropic porous medium of large depth has been given by. The solution has been obtained using inversion of the hodograph and conformal mapping technique. The triangular canal is a particular case of the trapezoidal canal. A family of curves for flat canal banks has been presented. However, seepage from a rectangular canal can not be computed from the analytical solution given for a trapezoidal canal.

The analytical form of these solutions, which contain improper integrals and unknown implicit state variables, is not convenient in estimating seepage from the existing canals and in designing canals. These methods have been simplified by numerical methods for easy computation of seepage in this study.

3.1 Equation Of Continuity

In many practical cases, the nature of the flow of water through soil is such that the velocity and gradient vary throughout the medium. For these problems, calculation of flow is generally made by use of graphs referred to as flow nets. The concept of the flow net is based on Laplace's equation of continuity, which describes the steady flow condition for a given point in the soil mass.

3.2 Seepage Loss

The seepage loss from a canal in a homogeneous and isotropic porous medium, when the water table is at a very large depth, can be expressed as

q = kyF

where

qs= seepage discharge per unit length of canal (m2/s);
k = hydraulic conductivity of the porous medium (m/s); *y* =
depth of water in the canal (m);
F = function of channel geometry
(dimensionless); and
yF= width of seepage flow at
the infinity. Hereafter, *F* will be referred to as the seepagefunction.

3.2.1 Triangular Section

For a triangular channel, Vedernikov (Harr 1962) gave thefollowing equation for the seepage function:

$$F = \frac{\pi m \int_0^1 (1 - t^2)^{-(0.5+\sigma)} t^{-(1-2\sigma)}\, dt}{\int_0^1 \cos^{-1} t (1 - t^2)^{-(0.5+\sigma)} t^{-(1-2\sigma)}\, dt}$$

where

m = side slope (dimensionless);
s = 1/p
cot21*m*; and
t = dummy variable (dimensionless). Using (2),for a given *m*,
F was obtained numerically by Gauss-Chebyshev integration. Repeating the process, *F* was obtainedfor a large number of *m* lying in the range 0 # *m* # 1,000.Using these computations the following equation for *F* wasfitted:

F = {[p(4 2 p)]1.3 1 (2*m*)1.3}0.77 (3)

is exact for *m* = 0, and *m* = `. Combining (1) and (3),the seepage discharge can be obtained for a triangular section.

3.3 Calculate Water Losses Through Seepage

Water storage reservoirs are created either by constructing a dam across a river or by just making a tank to store the water supplied from various sources. The intention behind constructing water storage reservoirs is based on the particular requirement of the person, organization or the government. The size of the reservoir varies- based on the need and can be as small as a pond to large reservoirs of capacity around millions of cubic meters. As the industrial sector had an enormous growth during the last century, the demand for water has increased. The need to construct larger dams is the outcome of this demand. At present, agriculture sector is the largest consumer of water for irrigation followed by domestic and industrial use.

In this increasing demand for water, industries having their own water reservoirs can't afford to have leakages especially when a large cost is involved in pumping it from the source. Water reservoirs are prone to losses through evaporation and seepage. In this article, we will discuss about seepage and its mitigation methods. Seepage is the slow escape of a liquid through porous material or small holes. In water reservoirs, seepage is the main crucial issue behind water losses. Seepage generally occurs when the water escapes vertically through the bottom of the pond and horizontal filtration of water through the dykes. The water releases through such conditions is called seepage water. For effective water management of reservoirs/dams/or small ponds, seepage calculation has become crucial. The stability of any water reservoir is inversely proportional to the seepage i.e. if the seepage is high; stability is low and vice versa. There are many factors that affects amount of seepage water from the reservoir. The reasons behind seepage are – wall of the reservoir, slope, soil type, bedrock type, dykes and volume and pressure of water.

3.3.1 New Reservoirs Have Greater Seepage Problem

New reservoirs release more seepage water than old reservoirs. It is mainly due to the good soil structure of the new reservoir. Soil particles bind together and form the soil structure. The arrangement of soil pores between these particles influence the water movement and hence extremely important in seepage assessment study. On the other hand, a reservoir that has been filled with water for some time breaks down the soil structure. It occurs due the deposition of organic materials at the bottom of the reservoir that seals the soil pores at the bottom of the reservoir and reduces permeability.

4.3.2 Seepage Calculation

There are two major types of seepage occurring in the artificial reservoirs. First is the horizontal seepage and the second one is vertical seepage. The amount of vertical seepage is dependent on the soil texture and soil structure at the pond bottom. For example, if the soil structure allows water to penetrate it, there will be more seepage. As discussed in the previous section, composition of soil particles forms the soil structure. If the soil is coarse or sandy, it is more permeable. The same case occurs with the horizontal seepage. The water escapes through the walls of the reservoirs due to higher permeability induced by the materials used to build the walls, water pressure and slope. As discussed in previous section of this article, there are various factors affects the rate of seepage. However, the material used in the construction and type of soil in the bed of the water reservoir, mainly determines the rate of the seepage. The table below gives the rate of seepage losses in millimeters per day from various soil types;

Table 1 Seepage losses due to soil type

Sl. No	Natural soil type	Seepage water losses (in mm/day)
1	Sand	25.00 – 250
2	Sandy loam	13.00 – 76
3	Loam	8.00 – 20
4	Clayey loam	2.50 – 15
5	Loamy clay	0.25 – 5
6	Clay	1.25 – 10

To calculate quantity of water escaping as seepage, following formula can be used;

Seepage water (in m^3/Day) = Seepage losses (in m/Day) X Surface area of the pond (in m^2)

This method uses average seepage rates for different soil types or geology units in ECBID. The seepage rates are estimated from seepage studies on laterals in the same soil or geology formation. The estimated seepage rate for the soil type or geology unit is multiplied by the wetted surface area of ECBID the canal or lateral (length multiplied by wetted perimeter) to estimate the seepage rate for the lateral or canal. The advantage of this method is that it does not require fieldwork and can be used on short sections of canal or lateral where other methods of estimating seepage may not be suitable. The disadvantage of this method is that it does not provide a direct measurement of seepage and should be viewed as an estimate. If more accurate unit seepage rates are required ,this approach will need to consider the varying flow stages that occur during an irrigation season. Higher flows during peak demand months will cause the wetted area to increase, thus increasing the unit seepage rate.

3.4 Calculation Of Conveyance Losses

- Ponding Loss Measurement Method
- Inflow–Out Flow Loss Measurement

3.5 Flow Nets

A set of flow lines and equipotential lines is called a flow net. A flow line is a line along which a water particle will travel.

3.6 Seepage Calculations Using Water Balance Techniques

A water balance for the entire irrigation season was performed on the other three laterals to estimate the volume of seepage. The unit seepage rate was calculated using the seepage data obtained from the annual water balance and geometric data obtained from design drawings of the lateral. The water balance was done for April through October (214 days). Design drawings give detailed geometry information for different reaches of the lateral. A wetted perimeter was calculated for each reach and then combined to find an overall wetted area
for the lateral.

3.7 Preventive Measures To Restrict Seepage

The preservation of irrigation water is often of primary importance to the agriculture development of a country.The reduction or eliminate of seepage losses in irrigation canals by means of linings assures better utilization of theconveyed water and an improved economic situation, seepage losses from earthen irrigation channels depend ona number of factors and vary from (30 to 50) percent of the discharge available at the head of an irrigation system.

3.8 Factors Affecting Seepage Rates From Dams

Theoretical, laboratory and fieldwork has confirmed that seepage rates from canals are affected by the following factors :

- Intrinsic permeability of soil.
- Length and shape of canal wetted perimeter.
- Depth of water in the canal.
- Location of ground water table.
- Constructions on ground water flow, e.g. presence of wells, rivers, drains, impermeable boundaries, etc.
- Soil suction in zone between ground water level and ground level.
- Viscosity of water (can be neglected).
- Salinity of water.
- Sediment load and size distribution.
- Age of canal.

3.9 Measurement Of Loss Due To Seepage

The seepage loss which occurs in an existing canal system or which may occur in the proposed canal system can be estimated by several methods. Some useful methods of calculating seepage loss are mentioned below.

- Permeameters And Seepage Meters
- Ponding Method
- Inflow And Outflow Method
- Occurrence Of Seepage Loss

The seepage loss may occur in two characteristic ways, namely:
(i) Absorption, and
(ii) Percolation,

3.10 Causes Of Seepage

- poor compaction of embankment soils
- poor foundation and abutment preparation
- rodent holes
- rotted tree roots and wood
- open seams
- cracks
- joints in rocks in dam
- coarse gravel or sand in the foundation or abutment
- clogging of coarse drains
- filters or drains with pores so large soil can pass through
- frost action
- shrinkage cracking in the embankment soil
- settlement of embankment soil
- uprooted trees
- earthquakes
- insufficient structural drainage
- trapped groundwater
- Excessive uplift pressures

3.11 Methods To Reduce Seepage Losses

Seepage loss from farm ponds can be reduced broadly by two ways. They are (i) reducing wetted surface area of the pond and (ii) using a cost effective sealant.

3.11.1 Reducing Wetted Surface Area Of Pond

3.11.2 Use Of Sealants

A newly constructed pond has self-sealing property by deposition of silt. The runoff of the catchment carries some silt and clay which gets deposited in the side and bottom of the pond and clogs the pore spaces of the soil. Consequently, the flow through the side and bottom of the pond is reduced and seepage loss is checked. Studies conducted at Dehradun and Rajkot of India reveal that seepage from a newly dug out pond reduced to a very low rate due to silting in a period of 8 years. Silting also reduces seepage rate in brick lined pond. A simple way to reduce water seepage, particularly if the pond bottom is very dry, hard and has open cracks in it, is to break the soil structure of the pond bottom before filling the pond with water. This is common practice is called puddling. It is accomplished through making the pond bottom saturated with water, allowing the water to be soaked into soil just enough to permit working and then, breaking the soil structure by puddling with a plough. A number of sealants/lining materials are now available to reduce the seepage loss. Lining of the pond, though costly, can reduce the seepage loss and improve the effective storage of the pond. Different lining materials used to reduce the seepage loss are plastic film, soil cement lining, bitumen lining, clay lining, cow dung lining, brick cement lining etc. Lining with brick masonry or cement mortar lining is most expensive but effective among them. Lining for reduction of seepage losses is feasible only for small pond. Descriptions of a few lining materials used for seepage control in the pond are given below.

- Clay Lining
- Cement Concrete Lining
- Asphalt Lining
- Brick Lining
- Bentonite Lining
- Alkali Soil Lining
- Soil Deflocculants
- Gleization

3.12 Conditions Of Seepage

Most dams have some seepage through or around the embankment as a result of water moving through the soil structure. If the seepage forces are large enough, soil can be eroded from the embankment or foundation. Seepage can also develop behind or beneath concrete spillways or headwalls. The signs of this type of problem could be cracking or heaving. Freezing and thawing will amplify the affects of seepage on concrete structures. The rate at which water moves through the embankment depends on the type of soil in the embankment, how well it is compacted, and the number and size of cracks and voids within the embankment. Saturation of embankment soils, abutments, and foundations due to seepage generally result in reduced soil strengths leading to sloughing, sliding and instability. In the worst case, seepage can result in total embankment failure if situations are not monitored. Many seepage problems and failures of earth dams have occurred because of inadequate seepage control measures or poor cleanup and preparation of the foundations and abutments. Seepage can lead to soil piping and embankment sloughing or sliding, both of which can lead to dam failure. Soil piping occurs when material is washed out at the base of the downstream face causing a hole to form underneath the dam. This hole is enlarged as more material is washed out by water flow, which increases due to the shorter flow path that gradually develops. Eventually a tunnel or pipe is created within the soil under the dam from the downstream to the upstream face which causes a collapse of the dam embankment. Seepage may be difficult to spot due to vegetation. Probing the soil in suspect areas can help to locate and identify whether seepage is present and the limits of the problem. Differences in vegetation and flowing water on the downstream side of embankments are the two most noticeable signs of seepage.

One approach to preventing failures of these dams from uncontrolled seepage under them is to increase the length of the flow path under the structures by using cutoff walls at the upstream and downstream edges of the dam. Designers of earthen and earth-rock dams adopted the philosophy of increasing the length of the seepage path used for concrete gravity dams. Concrete collars, also called antiseep collars were constructed at regular intervals along conduits through the dams to increase the length of the flow path of water along the outside of the conduit. The theory was that forcing water to take a longer seepage path would dissipate hydraulic forces and reduce the likelihood of piping at the downstream embankment toe. Antiseep collars were often constructed using the same materials used for the conduits. Probably the most common material was formed concrete. Steel, corrugated metal and plastic collars have been used for conduits made of similar materials. Collars were spaced at regular intervals along the conduit within the predicted zone of saturation of the earthfill zone. In the case of central core fills with rockfill shell zones, the collars were usually installed only within the compacted core of the embankment.

3.13 Drainage Methods

Seepage through rock foundations and abutments may be controlled reliably and economically for most dams by drainage measures. Even a shallow line of drain holes is effective for controlling uplift pressures below most gravity dams. This control could be improved, even for very unfavorable geologic conditions, by using deep drain holes.A homogeneous dam with a height of more than about 6 m to 8 m should have some type of downstream drain. The purpose of a drain is to reduce the pore water pressures in the downstream portion of the dam therefore increasing the stability of the downstream slope against sliding, and control any seepage that exits the downstream portion of the dam and prevent erosion of the downstream slope, also known as piping. The effectiveness of the drain in reducing pore pressures depends on its location and extent. However, piping is controlled by ensuring that the grading of the pervious material from which the drain is constructed meets the filter requirements for the embankment material.

3.13.1 Permeable Downstream Shells

At dam sites where there is an abundance of at least two different materials with significantly different permeabilities, a zoned dam may be constructed. In such cases permeable material is placed downstream of less permeable material, often with a transition zone between. For example, in a zoned dam which has a thick impermeable core and rests on an impermeable foundation, the flow paths within the downstream portion of the dam will be low. Thus seepage has a negligible effect on the stability of the downstream slope, which is the ideal condition in zoned earth dams.

4.CONCLUSION

The magnitude of potential seepage losses has been found to be nearly identical for the three cases simulated in the model (losing reach, gaining reach, and pumpage-affected reach). The seepage values ranged from 0.0 cubic foot per second per mile of channel length for a 0.5-foot surcharge applied for 1 day to 0.37 cubic foot per second per mile of channel length for a 3- foot surcharge applied for 100 days, when each surcharge was followed by a 180-day return flow from the aquifer. Seepage losses were calculated by inflow-outflow method. Three roughness coefficients were computed using the data, velocity hydraulic radius and slope of canal and minor. Followings conclusion could be drawn from the findings of the present study.

- Velocities of flowing water were found to be maximum in lined canal and minor as compared to unlined canal and minor.
- Maximum seepage loss was found to be 7.40 cumec/Mm^2 in the second section of unlined canal and minimum seepage loss was found to be 0.80 cumec/Mm^2 in first section of lined canal.
- Average seepage losses in lined and unlined canal were 0.836 to 7.063 cumec/Mm^2 respectively. If lining is provided the seepage losses could be reduced by nearly 88.16%.
- Average seepage losses in lined and unlined minor were 3.01 and 4.93 cumec/Mm^2 respectively. If lining is provided the seepage losses could be reduced by nearly 38.94%. 5. Average Manning‟ s roughness coefficient.

References

[1] T.Subramani, and R. Elangovan, “Planning Of A Ring Road Formation For Salem Corporation Using GIS”, International Journal of Engineering Research And Industrial Applications, Vol.5, No.II, pp 109-120, 2012
[2] T.Subramani,, S.Krishnan. and P.K.Kumaresan.., “Study of Ground Water Quality with GIS Application for Coonur Taluk In Nilgiri District.”, International Journal of Modern Engineering Research,Vol.2, No.3, pp 586-592, 2012.
[3] T.Subramani, and S.Nandakumar,, “National Highway Alignment Using Gis” International Journal of Engineering Research and Applications, Vol.2, Issue.4, pp 427-436, 2012.
[4] T.Subramani, and P.Malaisamy,“Design of Ring Road For Erode District Using GIS”, International Journal of Modern Engineering Research,Vol.2, No.4, pp 1914 - 1919,2012.
[5] T.Subramani., P.Krishnamurthi., “Geostatical Modelling For Ground Water Pollution in Salem by Using GIS”, International Journal of Engineering Research and Applications ,Vol. 4, Issue 6(Version 2), pp.165-172, 2014.
[6] T.Subramani., T.Manikandan., “Analysis Of Urban Growth And Its Impact On Groundwater Tanneries By Using Gis”, International Journal of Engineering Research and Applications, Vol. 4, Issue 6(Version 2), pp.274-282, 2014.
[7] T.Subramani., P.Someswari, “Identification And Analysis Of Pollution In Thirumani Muthar River Using Remote Sensing”, International Journal of Engineering Research and Applications, Vol. 4, Issue 6(Version 2), pp.198-207, 2014.
[8] T.Subramani., S.Krishnan., C.Kathirvel. S.K.Bharathi Devi., “National Highway Alignment from Namakkal to Erode Using GIS” , International Journal of Engineering Research and Applications ,Vol. 4, Issue 8(Version 6), pp.79-89, 2014.

[9] T.Subramani., A.Subramanian.,C.Kathirvel.,S.K. Bharathi Devi., " Analysis and Site Suitability Evaluation for Textile Sewage Water Treatment Plant in Salem Corporation, Tamilnadu Using Remote Sensing Techniques" , International Journal of Engineering Research and Applications , Vol. 4, Issue 8(Version 6), pp.90-102, 2014.

[10] T.Subramani. C.T.Sivakumar., C.Kathirvel., S.Sekar.," Identification Of Ground Water Potential Zones In Tamil Nadu By Remote Sensing And GIS Technique" International Journal of Engineering Research and Applications , Vol. 4 , Issue 12(Version 3), pp.127-138, 2014.

[11] T.Subramani., S.Sekar., C.Kathirvel. C.T. Sivakumar, "Geomatics Based Landslide Vulnerability Zonation Mapping - Parts Of Nilgiri District, Tamil Nadu, India", International Journal of Engineering Research and Applications, Vol. 4, Issue 12(Version 3), pp.139-149, 2014.

[12] T.Subramani., S.Sekar., C.Kathirvel. C.T. Sivakumar, "Identification Of Soil Erosion Prone Zones Using Geomatics Technology In Parts Of North Arcot And Dharmapuri District", International Journal of Engineering Research and Applications, Vol. 4, Issue 12(Version 3), pp.150-159, 2014

[13] T.Subramani, R.Vasantha Kumar, C.Krishnan "Air Quality Monitoring In Palladam Taluk Using Geo Spatial Data", International Journal of Applied Engineering Research (IJAER),Volume 10, Number 32, Special Issues pp.24026-24031,2015

[14] T.Subramani,"Identification Of Ground Water Potential Zone By Using GIS", International Journal of Applied Engineering Research (IJAER), Volume 10, Number 38, Special Issues, pp.28134-28138, 2015

[15] T.Subramani, M.Sivagnanam , " Suburban Changes In Salem By Using Remote Sensing Data" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, May 2015 , pp. 178-187 , ISSN 2319 - 4847. 2015

[16] T.Subramani, P.Malathi , " Drainage And Irrigation Management System For Salem Dist Tamilnadu Using GIS" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 199-210 , 2015

[17] T.Subramani, P.Malathi , " Land Slides Hazardous Zones By Using Remote Sensing And GIS" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 211-222 , 2015

[18] T.Subramani, D.Pari, "Highway Alignment Using Geographical Information System" , IOSR Journal of Engineering, Volume 5 ~ Issue 5 ,Version 3, pp 32-42, 2015

[19] T.Subramani, G.Raghu Prakash , " Rice Based Irrigated Agriculture Using GIS" , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) , Volume 5, Issue 3, pp. 114-124 , 2016.

[20] T.Subramani, E.S.M.Tamil Bharath , " Remote Sensing Based Irrigation And Drainage Management System For Namakkal District" , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) , Volume 5, Issue 3, pp. 071-080 , 2016.

[21] T.Subramani, A.Janaki , " Identification Of Aquifer And Its Management Of Ground Water Resource Using GIS In Karur" , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) , Volume 5, Issue 3, pp. 081-092 , 2016.

[22] T.Subramani, C.Kathirvel , " Water Shed Management For Erode District Using Gis " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) , Volume 5, Issue 3, pp. 093-103 , 2016.

[23] T.Subramani, A.Kumaravel , " Analysis Of Polymer Fibre Reinforced Concrete Pavements By Using ANSYS" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 5, Issue 5, pp. 132-139 , 2016 .

[24] T.Subramani, S.Sounder , " A Case Study And Analysis Of Noise Pollution For Chennai Using GIS" , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) , Volume 5, Issue 3, pp. 125-134 , 2016.

[25] T.Subramani, K.M.Vijaya , " Planning And Design Of Irrigation System For A Farm In Tanjavur By Using Remote Sensing" , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) , Volume 5, Issue 3, pp. 135-146, 2016.

[26] T.Subramani, G.Kaliappan , " Water Table Contour For Salem District Tamilnadu using GIS" , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) , Volume 5, Issue 3, pp. 147-158 , 2016.

[27] T.Subramani, K.Kalpana , " Ground Water Augmentation Of Kannankuruchi Lake, Salem, TamilNadu Using GIS – A Case Study " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) , Volume 5, Issue 3, pp. 210-221 , 2016.

AUTHOR

Prof.Dr.T.Subramani Working as a Professor and Dean of Civil Engineering in VMKV Engineering College, Vinayaka Missions University, Salem, TamilNadu, India. Having more than 27 years of Teaching experience in Various Engineering Colleges. He is a Chartered Civil Engineer and Approved Valuer for many banks. Chairman and Member in Board of Studies of Civil Engineering branch. Question paper setter and Valuer for UG and PG Courses of Civil Engineering in number of Universities. Life Fellow in Institution of Engineers (India) and Institution of Valuers. Life member in number of Technical Societies and Educational bodies. Guided more than 400 students in UG projects and 300 students in PG projects. He is a reviewer for number of International Journals and published 174 International Journal Publications and presented more than 25 papers in International Conferences.

K.Ashok kumar completed his Diploma in Civil Engineering in Swamy Abedhananda Polytechnic Thellar. He is working as Union Overseer in Olakkur Block in Tamilnadu Rural Devolopement Departrment and Panchayat Raj. He is also having Tamil nadu State Divisional Seceratory in Union Overseer Association. He Is doing BE in the Branch of Civil Engineering @ Vinayaka Mission Kirupananda Varriyar Engineering College, Salem.

P Senthil completed DCE in the (SSP) Srinivasa Subbaraya Polytechnic, Puthur in Nagapatnam District. Now working as union overseer in rural development department in Vilupuram district. Currently he is doing BE in the branch of Civil Engineering in Vinayaga Mission Kirupanada Variyar Engineering College at Salem

A.Ganesan completed his Diploma in Civil Engineering in Adhiparasakthi Polytechnic Melmaruvathur. He is working as Union Overseer in Melmalaiyanur Block in Tamilnadu Rural Devolopement Departrment and Panchayat Raj. He is also having Villupuram District Joint Secerastory in Union Overseer Association. Is doing BE in the Branch of Civil Engineering at Vinayaka Mission Kirupananda Varriyar Engineering College, Salem.

G.Gunasekaran completed his Diploma in Civil Engineering in MPN, MJ Polytechnic, Chennimalaiin Erode district. He is working as Junior Draughting Officer in Highways Department in Djarmapuri District. Is doing BE in the Branch of Civil Engineering at Vinayaka Mission Kirupananda Varriyar Engineering College, Salem.