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"Seepage through Canals" – A Review

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Abstract: Seepage is a phenomenon of slow movement of water through a porous. As these days fresh water is in very limited quantity, it is required to prevent the seepage loss. One of the major problems in irrigation canals is water losses due to seepage in unlined and lined canals. Unlined canal lose a substantial part of the usable water through seepage to that of lined canal. The various seepage measurement and design methods were proposed by previous researchers. The extensive study of research papers is carried out for this review especially related to determination of the minimum loss through the canal.
Keywords: Canal design, Measurement, Seepage loss.

I. INTRODUCTION

Seepage losses from channels for a number of irrigation systems in the former U.S.S.R. were estimated as amount up to 40-50% of the transported water quantity. Thus, seepage loss from irrigation canals constitutes a substantial percentage of the usable water. Canals continue to be major conveyance systems for delivering water for irrigation. Seepage lose is the major and the most important part of the total water loss. Water loss due to seepage from the canal is governed by hydraulic conductivity of the subsoil, canal geometry, location of water table relative to the canal, and several other factors. Many times the area to be irrigated lies very far from the source, and hence requires long transmission canals. It is not economical to continue the same section throughout the length of a long transmission canal. Instead the transmission canal should be divided into subsections or reaches and the cross section for each of the subsections must be designed separately. Several analytical solutions have been presented for different canal cross sections, shape, and boundary conditions. Darcy's equation and unsaturated- flow theory are used to calculate flow through earth linings that are placed in ponds or channels to reduce seepage. Seepage calculations of hydraulic structures are routinely performed using two-dimensional (2D) analysis. It is not always appropriate to facilitate the solution by simplifying the problem to be 2D. The soil formation under the structure is heterogeneous and the problem may have arbitrary geometry for that 3D analysis would be adopted.

II. LITERATURE REVIEW

The determination of seepage and design of canal to minimize the seepage is carried out by various researchers and a comprehensive review is discussed in the following paragraphs. Herman Bouwer (1982), in his study carried out the design for earth linings for seepage. Earth lining is a layer of clay and some other soil material to reduce the seepage loss. The calculation of seepage was done by using Darcy's equation. Saturated hydraulic conductive K_s can be determined by using air-entry permeameter, in situ and undisturbed soil samples were tested for determination of K_s. The relationship between K and h and between Θ and h are subjected to hysteresis. Measurement of saturated hydraulic conductivity of earth lining was done in laboratory. The time taken by the pollutants to travel downward was predicted. The ground water mounds and swamped operation was done. The hydraulic conductivity of mine-tailings pounds was taken into consideration.

A. Field Studies

Mohamed Fawzy Bakry and Ahmed Abd El-Megeed Awad (1997), considered two main conveyance canals which are located in the Northern –Eastern Delta region. As the canal was conveyance canal, the authors adopted inflow and outflow method. The field measurements were taken as inflow and outflow rate, geometrical parameters of canal c/s, collection of soil sample from the bed and bank and water sample. The laboratory tests were conducted for the determination of physical properties of the collected soil samples and percentage of the suspended soil materials in water. Researches developed four equation based on inflow and outflow method and boundary material. The equation was only applicable for canals having discharge ranging between 2 and 20 meter cube per sec.

In the study of H. E. M. Moghazi (1997), soil was classified as sandy to sandy loam soil and with its saturated hydraulic conductivity was about 10.7 cm/h. the two field channels of length of 50m each were excavated, with longitudinal slope of 1:100, channel had trapezoidal section with bed width of 45 cm and side slope of 3:2. Water losses from the channel were investigated for three cases i.e. by uncompact –earthen channel, compacted channel bed and channel lined with prefabricated jute mates coated with oxidized bitumen emulsion on both faces. After compacting the channel bed, the penetration resistance values were measured at eight location at different depth. Discharge was determined by float method and ponding method was use to find out the losses from the channel. He concluded that compaction done by passing tractor wheel reduced the seepage but the more reduction in seepage is obtained when the canal is lined by prefabricated bitumen jute mates.

For study presented by Magdy H. Mowafy (2001), the area was of Ismailia Canal command. Seepage losses were calculated in seven different sections. The Empirical formulae used were Mortiz formula (USSR), Molesworth and Yennidunia (Egypt), Indian formula, Pakistanian formula, and Hungarian formula. The Analytical equation were also used i.e. Vendernikov, Farouk Mohamed, and Molesworth and Yennidunia. The study concludes that the analytical equations by Molesworth and Yennidunia for seepage computation in all canals yields better seepage loss estimates which are similar to the Egypt canals.

Jean-Pierre Bardet and Tetsuo Tobita (2002) had proposed the finite difference equation for confined seepage. Iterative calculations were done in spreadsheet to find out the successive over-relaxation solution. Flow lines and flownet for both confined and unconfined isotopic and anisotropic conditions for the seepage loss were obtained. The study illustrated application of numerical methods in one-dimensional water column with free surface, and two dimensional free surface for rectangular dam with tail water, with a toe drain, with an impermeable sheet wall, dam with a slanted face and nonhomogeneous rectangular dam. This method does not required formation and reformation of a global matrix system. This methods required number of iteration.

Bikram Saha (2015) used different Empirical formula to determine the seepage losses (Viz. Mortiz formula (USSR), Molesworth and Yennidunia (Egypt), Indian formula, Pakistanian formula, and Hungarian formula). The evaporation loss was found out by using empirical equation. Geosynthetic were used as lining material to solve the seepage losses. The lining reduce the seepage about 18% to 19%. The lining material depends on the budget, locally available materials, and on soil characteristics for infiltration.

B. Design Aspects

Prabhata K Swamee and Deepak Kashyap (2013), Canal sections can be divided into two categories (i.e., polygonal and nonpolygonal). In this design numerical algorithm, numerical solution, seepage width equations and optimal section shape for circular and exponential section were considered. They obtained the explicit equations for seepage loss from circular and exponential canal sections to conclude their study. They showed that equation for the geometrical element for minimum seepage loss from the canal section can be obtained by using explicit equation.

Bhagu R. Chahar (2013) had done the analysis of seepage for polygonal channels. Analytic solution was carried out in which it was considered that seepage is two dimensional. The study included computation of seepage quantity, variation in seepage velocity for minimum seepage velocity along the bed of the channel, the relationship for the seepage velocity along the side slope of channel and minimum seepage along the side slope. For a slit, the width at water surface (T) approaches zero. The study included solutions for the variation in the seepage velocity along the channel perimeter and the quantity of seepage for channel.

Prabhata K Swamee et al. (2014) had designed a minimum water loss canal section in which they considered the seepage and evaporation loss. They found out the total water loss for triangular, rectangular and trapezoidal sections by using Swamee equation and also the resistance equation. They used non-dimensionalization variable to reduce the water loss. The determination of optimal canal section shape was reduced to minimization using non dimensional for water loss. The study summarized the explicit design equations and optimal section shape coefficients for triangular, rectangular, and trapezoidal sections to carry out the design of minimum water loss canal section. The study of Ms. K. D. Uchdadiya and Dr. J. N. Patel (2014) indicates that seepage rates are obtainable either by direct measurement or by estimation. In this study the simplified and approximated expressions proposed by Swamee et al., were adopted to formulate the seepage loss from unlined and lined canal with different material by assuming a different permeability coefficients. They concluded that the lining is to be provided to the unlined canal. The velocity of water in the canal will increase as the surface of the canal will be smooth and due to this, rugosity coefficient is improved. This will lead increase in the discharge carrying capacity of the canal. Prabhata K. Swamee et al. (2015) considered a lined canal and designed it for the condition of uniform flow an average velocity of 0.6 to 0.9 m/s. This facilitated prevention of sedimentation when the silt load of the flow is low and a velocity of 0.75 m/s is usually sufficient to prevent the growth of vegetation. The study included aspects like methodology problem formulation, Nondimensionalization, Least-Cost Section Design Equations for Each Subsection, Optimal Cost and Length of each subsection, Single Section Design of Transmission Canal and Variable Section Design of Transmission Canal. A direct optimization procedure may be adopted for the optimal design of irrigation canal sections and for the transmission canal but they require considerable amount of programming and computation. The optimal design variables of a canal can be obtained in single-step computations. The proposed method can be extended in developing equations for the optimal design of a transmission canal having unequal cost of transitions and unequal length of subsections.

Prabhata K Swamee et al. (2017) considered that seepage loss in design for triangular, rectangular, and trapezoidal sections, resistance equation given by Swamee (1994) was used for optimization algorithm and optimal section shape design. Seepage from a triangular canal is minimum for m =1.244. A rectangular channel with a ratio of bed width to normal depth = 2.513 has minimum seepage. Among the optimal sections, the optimal trapezoidal section loses the least seepage. The sensitivity analysis for the trapezoidal canal section design has revealed that the optimum is less sensitive to the increase in bed width and more sensitive otherwise.

III. CONCLUSION

Many previous researchers have studied the seepage loss. Researchers used different design method for minimizing the water loss from the canal and different methods were used to measured seepage from the unlined and lined canals. The sensitivity analysis for the trapezoidal canal design is revealed that it is important to consider evaporation loss in arid region. Analytical solutions that require minimal data input are considered to be favorites. Linings of canal can reduce seepage loss significantly if lining material and method of applying liner are properly designed and implemented.

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