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Seepage losses through unlined and lined canals

Research Article

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Abstract: The losses from canals need to be minimized to ensure the efficient performance and effective utilization of water. Seepage loss is one of the major components of water loss from canals. Seepage rates are obtainable either by direct measurement or by estimation. Measurement of seepage from large canals by ponding method is practically impossible due to continuous running and large widths of canals. Inflow-outflow method is also not suitable for canal seepage measurement in short reaches of canals due to small differences. Seepage meter technique may require a large number of measurements to arrive at an average value of canal seepage. Analytical solutions are over simplified for estimation of canal seepage due to several assumptions which are rarely met in the field. During this investigation the seepage analysis of unlined and lined irrigation canal has been done depending on equations derived by Swamee et al. Average seepage losses in the unlined canal are 0.415 cumec, in Brick lined canal are 0.0511 cumec, in P.C.C. lined canal are 0.0028 cumec and in P.C.C. with LDPE film lined canal are 1.2×10^{-4} cumec. If lining is provided the seepage losses could be reduced by nearly 87.68%, 99.30%, and 99.97% respectively.

MSC: xxxx

Keywords: Irrigation • Lined canal • Measurement • Seepage losses

1. Introduction

Conservation of water supplies is becoming increasingly important as the demand continues to increase and new sources of supply became harder to find. The time is rapidly approaching when the only additional water supplies available will be the saving from those now being lost through canal seepage and field losses. Principles of conservation require that full use be made of our water supplies, and the greatest results probably can be accomplished on most irrigation projects by a reduction of seepage from canals up to the farmerâĂŹs fields. Water is one of the most valuable natural resources. With the increase of population, the development and management of water resources have become essential for sustainable use of water resources for domestic, irrigation and industrial purpose throughout the world.

An open channel may be rigid boundary (lined) or mobile boundary (unlined) section. Unlined channels lose a substantial part of the usable water through seepage. Seepage loss results not in depleted freshwater resources but also causes water logging, salinization, and ground water contamination. Canals are lined for slowing the seepage loss. A perfect lining would prevent all the seepage loss, but canal lining deteriorates with time. Cracks in the lining may develop anywhere on the perimeter due to settlement of the subgrade, weed growth in the canal, construction defects and use of inferior quality lining materials, weathering, etc.

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2. Study area

Kim branch canal is branch of kakrapar right bank main canal which is provided in the ghaludi village of kamrej taluka, Surat district, Gujarat. It is one of 69 villages in kamrej Block along with villages like Shekhpur and Antroli. Nearby railway station of Ghaludi is Surat.

Total length of Kim branch canal is 10565ft. Total sub minor canal of Kim branch are 11 from which 3 minor left side canal, 5 minor right side canal and others 3 are T.W.C., T.W.C.B., and Kim tail sub minor branch. The total C.C.A. under the Kim branch is 1710 hector per season. Major crops are Sugarcane, paddy, wheat and minor crops are jowar, millet, vegetables and cotton.

3. Methodology

Seepage is the most dominant processes by which water is lost in the canal. Thus, for the effective operational planning and management of an irrigation system, a dependable forecasting of the seepage is very important. Seepage rates are obtainable either by direct measurement or by estimation. The exact analysis of seepage loss from the canals is quite complex. In the present 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 coefficient.

4. Predictions of seepage losses

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 the conveyed water and an improved economic situation, seepage losses from earthen irrigation channels depend on a number of factors and vary from (30 to 50) percent of the discharge available at the head of an irrigation system (Abu Gulul,1975).

4.1. Factors affecting seepage rates from canals

Theoretical, laboratory and fieldwork has confirmed that seepage rates from canals are affected by the following factors (Abu Gulul, 1975):

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

4.2. Seepage loss through different lining materials

Canals are lined to control the seepage. But canal lining deteriorates with time and hence, significant seepage losses continue to occur from a lined canal. Therefore, seepage loss must be considered in the design of a canal section. Providing perfect lining can prevent seepage loss from canals, but cracks in lining develop due to several reasons and performance of canal lining deteriorates with time. A well maintained canal with 99In this study studied the seepage losses through different channel lining materials is calculated. Permeability Coefficient for different material is shown in the table.

Table 1. Permeability k for different material (Thandaveswara, B.S.)

Sr. No	Type of lining	Permeability $k(m/s)$
1	Unlined canal	4.5×10^{-5}
2	Brick lining	6.02×10^{-6}
3	P.C.C. lining	0.331×10^{-6}
4	P.C.C. with LDPE film	0.141×10^{-7}

4.3. Estimation of seepage losses from canals

The seepage loss from a canal in an unconfined flow condition is finite and maximum when the potential difference is very large e.g. when the water table lies at very large depth. The steady seepage loss from an unlined or a cracked lined canal in a homogeneous and isotropic porous media can be expressed as:

$$q_s = k\, y_n F_s \tag{1}$$

where q_s = seepage discharge per unit length of canal (m^2/s); k = coefficient of permeability (m/s); y_n = normal depth of flow in the canal (m); and F_s = seepage function (dimensionless), which is a function of channel geometry.

The seepage function can be estimated for different sets of specific conditions for a known canal dimension. The analytical form of these solutions, which contain improper integrals and unknown implicit state variables, are not convenient in estimating seepage from the existing canals and in designing the canals considering the seepage loss. These methods have been simplified using numerical methods for easy computation of seepage function by Swamee et al., for trapezoidal section seepage function is given by:

$$F = \left(\left\{ [\Pi(4-\Pi)]^{1/3} + (2m)^{1/3} \right\}^{(0.77+0.462m)/(1.3+0.6m)} + \left(\frac{b}{y} \right)^{(1+0.6m)/(1.3+0.6m)} \right)^{(1.3+0.6m)/(1+0.6m)} \tag{2}$$

where, m= Side Slope, b = width of channel, y= depth of flow

The seepage function can be estimated for different sets of specific conditions for a known canal dimensions.

5. Results and discussion

The study compared estimated seepage losses from unlined and lined canal for different material by using Swamee et al., method which is shown in Table 2.

Table 2. Seepage analysis

Sr. No	Canal name	Seepage losses from unlined Canal (Cumec)	Seepage losses from brick lined (Cumec)	Seepage losses from PCC lined (Cumec)	Seepage losses from LDPE lined (Cumec)
1	1L Ex Kim branch	0.0820	0.0109	0.0006	2.6E-05
2	1R Ex Kim branch	0.1042	0.0136	0.0008	3.2E-05
3	2L Ex Kim branch	0.1396	0.0185	0.0010	4.3E-05
4	2R Ex Kim branch	0.0609	0.0081	0.0004	1.9E-05
5	3L Ex Kim branch	0.0541	0.0071	0.0004	1.7E-05
6	3R Ex Kim branch	0.1112	0.0143	0.0008	3.4E-05
7	T.W.C. Ex Kim branch	0.0772	0.0101	0.0006	2.4E-05

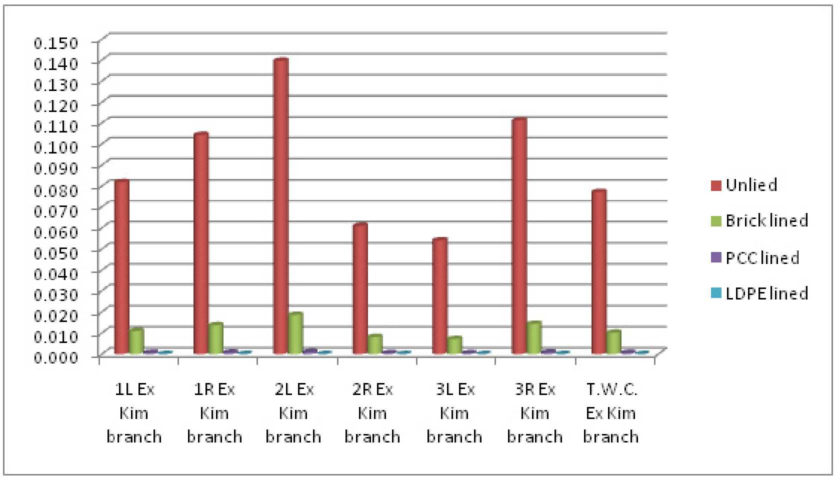

Fig. 1. Comparison of seepage losses

6. Conclusions

As the lining is to be provided on existing canal which is unlined canal, the velocity of water in the canal will increase as the surface of the canal will be smooth due to rugosity coefficient is improved. This will increase the discharge carrying capacity of the existing canals. As a result of proposed lining of the canal, seepage losses, water logging, silting and maintenance cost of canal can be significantly decreased. Whatever quantity of water saved can be used for irrigation.

Average seepage losses in the unlined canal are 0.415 cumec, in Brick lined canal are 0.0511 cumec, in P.C.C. lined canal are 0.0028 cumec and in P.C.C. with LDPE film lined canal are 1.2×10^{-4} cumec. If lining is provided the seepage losses could be reduced by nearly 87.68%, 99.30%, and 99.97% respectively.

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