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NOTATIONS

[illegible] dimensions :

A	=	cross sectional area of canal	[L^2]
a	=	absolute surface roughness	[L]
a_o, a_1, a_2, a_3	=	integration constants	
b	=	bed width of canal	[L]
C	=	factor defining the maximum bending moment in the lining depending on the relative rigidity of lining and foundation	
d	=	depth of water in the canal	[L]
E_o	=	Modulus of elasticity of soil	[F/L^2]
E	=	Modulus of elasticity of concrete	[F/L^2]
f	=	maximum allowable tensile stress for concrete	[F/L^2]
I	=	moment of inertia	[L^4]
i	=	water surface slope	
K, K_1	=	parameters depending on canal dimensions	
L	=	length of beam	[L]
m	=	hydraulic mean depth	[L]
M	=	bending moment	[F.L]
n	=	coefficient of rugosity	
P(x)	=	Soil reaction	[F/L]
Q	=	shearing force	[F]
q	=	the load over the lining	[F/L]

V	=	volume of concrete	$[L^3]$
v	=	displacement of elastic foundation	$[L]$
v_*	=	shear velocity	$[L/T]$
W_p	=	wetted perimeter of cross section of canal	$[L]$
x, y	=	distances	$[L]$
α	=	Modulus of relative rigidity of lining w.r.t. soil underneath	
β	=	ratio between bed width to water depth of canal	
γ_w	=	specific weight of water	$[F/L^3]$
Δ	=	thickness of boundary layer	$[L]$
δ	=	thickness of lining	$[L]$
μ	=	coefficient of friction between concrete and soil	
u_o	=	Poisson's ratio	
ν	=	kinematic viscosity of water	$[L^2/T]$

INTRODUCTION

As well known all over the world, nearly one-third of the available water for irrigation is lost by evaporation and seepage during its conveyance in open irrigation systems. Another one-third is lost by the subsurface drainage system during field surface irrigation, i.e. only about one-third of the available water is used in actual irrigation.

Since the process of water storage is too costly, we have to ensure the optimum water use for irrigation to increase the reclaimed areas as much as possible. For this purpose, we have to minimize the losses from canals so as to get the optimum water use.

Concrete lining is one of the most widely used types for canal lining. In general, the existing methods for the design of thickness of lining are very poor. The total cost of construction is tightly linked to the lining thickness especially for canals with big discharges. The use of the theory of beams and slabs on elastic foundations may lead to convenient results for the choice of lining thickness. This work is an attempt in this direction.

On the basis of such method, the parameters of canal section has to be determined to give the optimum dimensions of the canal.

This work is carried to give some answers to help in finding a solution for this problem.

C H A P T E R I

SEEPAGE LOSSES FROM IRRIGATION CANALS

1. Practical Examples of Seepage Losses :

In Egypt, before the construction of the High Dam, a big amount of silt which was carried by the water of the River Nile deposited on the bed and sides of canals, thus decreasing considerably the amount of seepage water.

In Lower Egypt, normal seepage loss in transit from the canal head to the field was estimated to be about 8%.

In Upper Egypt, it is said to vary between 5% and 15%, with a mean of 10% of the supply at the head, according to the nature of soil and length of canal. During the critical summer months, normally between the 1st of May and 10th of August, the main canals of Upper and Lower Egypt as a whole, draw an average discharge of about 15 milliard m^3 and the losses through seepage are estimated to amount to about 1.5 milliard m^3. The enormity of this seepage loss in the critical months could be well appreciated in view of the fact that it represents about 30% of the capacity of the Aswan Reservoir.(9)

Now, after the construction of the High Dam, the anticipated seepage loss from new canals will be much higher than that in previous time, due to the fact that most of the silt carried by water has been deposited in Nasser Lake up stream the dam and the water flowing through these canals is almost clear water. Moreover, most of the new canals pass through purely permeable sandy regions.

In India, attempts were made in early days (1875) to measure the transit losses in canals and distributaries. Losses of water varying from 13.1% to 19.15% of the supply at the head in main and branch canals, and from 20 to 30% in distributaries and minors were reported on the Upper Bari-Doab Canal, which has then been in operation for nearly 18 years.(17)

The U.S. Bureau of Reclamation reports that even in U.S.A. with better management of irrigation distribution systems, at least 25% of the water supplies are lost through seepage.

In U.S.S.R., actual observation of seepage losses has been based on the first stage of Kara-Kum Canal, which has a total length of about 400 km. For a length over 300 km., the canal runs through sand-hills, valley, hammock and rigid sand. The results of the actual observation for one full year show that the average seepage losses amounted to 43% of the overall discharge at the head (by volume); while during some months the losses reached even 60% of the discharge.

In Cyprus Island, seepage losses are computed for an unlined canal in terms of the percentage of the entire water that enters the canal for a whole irrigation season, in the reach of the canal from its source to the point of water application in the field. The amount of seepage was estimated from 20% to 45% depending on the nature of soil.

In Greece, where most of the canals are ordinary unlined earthen channels, the seepage losses are reported to be of the order of 40 to 50% of the initial discharge.

In Czechoslovakia, the Research Institute at Prague estimates the seepage losses at only 7 to 10% of the head discharge as an average value.

In France, on the canal of Donziere Mondragon (bed width 85 meters, side slope 3:1, depth of water 10 meters and length 17 km.) which passes through highly permeable soil, when water was released into the canal for the first time [illegible], the seepage loss was (16 m^3/sec.), but due to progressive silting of the canal by the heavily silt-laden water of the river Rhone the losses subsequently were reduced to only about 3 m^3/sec. in 1957.

Observations in the Alsace France plain on the old canal of Mardt (25 km. main canal and 20 km. secondary canals) constructed between 1890 and 1912, showed that the canal irrigated only 748 hectares against 3000 hectares provided for by the project, because of the heavy infiltration losses.

Although there is a large variation in estimating losses in different cases, yet generally seepage losses are of considerable magnitude in their cumulative effect. It has to be remembered that seepage does not only cause loss of valuable water, but also proves detrimental for soils and crops with serious effect on the national income of the country.

Lining of canals for such cases is recommended not only for protection against scour and weed growth but also for the purpose of decreasing the seepage losses.

[illegible] page losses from a canal or lateral. Linings are most universally used in controlling seepage losses, and satisfactory linings can be constructed in numerous ways and with different materials.

2. <u>Field measurements for evaluation of seepage losses</u> :

To evaluate the water saved by lining, information must be available on the losses before and after lining. There are three methods for determining seepage losses.

2.1. Inflow and outflow method, using various measuring devices to determine the quantity of water flowing in and out of a selected section of canal.

2.2. Tappoon or ponding method, in which a selected canal section is segregated by dykes at each end. Seepage losses are most accurately determined by measuring the inflow required to maintain the water level in the ponded section at a given level. Field experience has indicated that "the ponding method is most accurate and dependable."

2.3. Permeameters, which consist of a pipe placed upright in a canal, such that the end is firmly embedded in the subgrade. The pipe is then filled with [illegible] ring the rate of water drops in the pipe. Improvements have been made in the application of this principle by using a flexible tube to convey water from a flexible bag, which is submerged in the flow and contains a known quantity of water, to a special device pressed into the canal bed like an inverted pan or dish.

3. Empirical formulae for estimation of seepage losses :

Seepage estimates are made from empirical equations when field data or observations from existing canals are not possible. Some typical formulae used in various countries are given in the following sections.

In Egypt, Molesworth and Yenidunnia Formula was used.

$$S = CLP\sqrt{R}$$

where

S = seepage and evaporation losses in cubic meter per second,

L = length of canal in kilometres,

P = average wetted perimeter in metres,

R = hydraulic mean depth in metres.