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Estimate Seepage Losses in Irrigation Canal System

KEYWORDS: Seepage, percolation, cracking, water surface profiles, slops, discharge, and water level

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ABSTRACT *The conveyance efficiency in irrigation projects is poor due to seepage, percolation, cracking, and damaging of the earth channel. Seepage loss in irrigation water conveyance system is very significant, as it forms the major portion of the water loss in the irrigation system. One of the main problem that meet the Ministry if Irrigation and Water Resources is that about 80% from its total length passing through silt clay soil. The quantity of seepage to surrounding area varies from section to other. The seepage losses affect the water surface profiles, slops, discharge, and water level. . Various methods are used to estimate the canal seepage rate. The main objective of this research are evaluating seepage losses at different critical sections and comparing between different empirical, analytical and field measure result.*

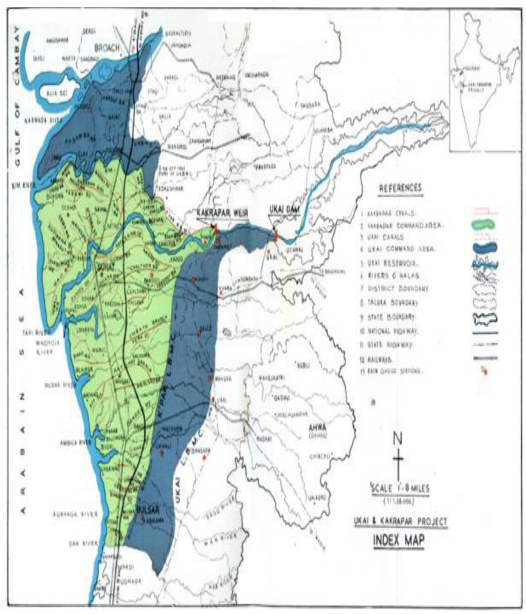
INTRODUCTION

On Ukai-kakrapar projects comes under surat canal division. Kakrapar Right Bank Main Canal is one of the important irrigation canal in Gujarat. Ukai- Kakarapar project was constructed in two stages on River Tapi. In first Stage Kakarapar weir was constructed between 1949-1954 at Village Kakarapar; Vyara Taluka of Surat District, about 85 Km upstream of Tapi's confluence with the Arabian Sea.In the final developing stage, the canal discharge is 2480 cusec In the second stage, Ukai Dam was constructed in 1975 on River Tapi near village Ukai in Songadh Taluka of Surat District, about 110 km upstream of Tapi's confluence with Arabian Sea. The dam was planned to impound 6614 MCM as water of live storage and thereby confirming up of existing area of 204080 Ha area and brought additional 127477 Ha area under irrigation served through Ukai Right Bank Canal and Ukai Left Bank Canal. Thus total command area of Ukai – Kakarapar project is 331557 Ha spread over in 5 Districts taking into consideration additional Area brought under command due to Ukai scheme through two canals i.e. U.R.B.M.C with 61,309 Ha and U.L.B.M.C with 66,168 Ha.

STUDY AREA

A part of kakrapar Right Bank Main Canal in 0 to 200RD is selected for study purpose. Fig(1) shows the Index map of Command area under Ukai & Kakrapar and Table(1) shows the dimensions and characteristics of different sections. The study area, K.R.B.M.C. is totally rural area in south zone of Gujarat, At present cropping pattern has to be changed so more water required for irrigation purpose but due to unlined canal wastage through seepage is more than for present and future demand of water for irrigation purpose. The total length of canal is 60KM.

Figure 1: Index map of Command area under Ukai & Kakrapar



Sources: Irrigation department

TABLE – 1 GENERAL DETAILS (THE DIMENSIONS AND CHARACTERISTICS OF DIFFERENT SECTIONS)

From KM	TO KM	L(KM)	Q(m3/sec)	B(m)	H.G=i	D(m)	P(m)	A(m2)	V(m/s)
0	16357	16.357	61.397	27.44	0.0001	2.9	37.896	92.191	1.087
16357	25201	25.201	63.509	22.56	0.000167	2.84	32.8	76.169	1.073
25201	28040	28.04	61.733	24.09	0.000152	2.77	34.077	78.239	1.056
28040	42988	42.988	60.676	23.78	0.00015	2.77	33.767	77.38	1.056
42988	46795	46.795	60.253	22.56	0.00015	2.84	32.8	76.169	1.073
46795	52280	52.28	54.911	21.1	0.0003	2.28	29.321	55.906	0.932
52280	56093	56.093	53.262	19.5	0.0003	2.34	27.937	53.843	0.942
56093	57813	57.813	54.046	16.3	0.00025	2.74	26.179	55.923	1.048
57813	59293	59.293	52.227	15.7	0.00025	2.74	25.579	54.279	1.048
59293	60980	60.98	51.6	17.5	0.0002	2.74	27.379	59.211	1.048

Source: From irrigation department

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background and methodology

A During the passage of water from the main canal to the outlet at the head of the water course, water may be lost either by evaporation from the surface or by seepage through the peripheries of the channels. These losses are sometimes very high, of the order of 25 to 50% of water diverted into the main canal. In determining the designed channel capacity, a provision for these water losses must be made. The provision for the water lost in the watercourses and in the fields is however, already made in the outlet discharge factor, and hence, no extra provision is made on that account.

1 . Evaporation losses from tha water surface
2 . Seepage: (i)Percolation, (ii) Absorption:

In percolation, there exist a zone of continuous saturation from the canal to the water-table and a direct flow is established. Almost all the water lost from the canal, joins the ground water reservoir.

In absorption, a small saturated soil zone exists around the canal section, and is surrounded by zone of decreasing saturation. A certain zone just above the water-table is saturated by capillarity. Thus, there exists an unsaturated soil zone between the two saturated zones

OBJECTIVE OF RESEARCH

To. Most of the canals constructed in earlier days i.e. before 40-50 years were unlined as at that time fund for development was limited and priority for the development in other sectors were to be given appropriate weightage. Once the water for irrigation was made available, the crop pattern also changed and hence demand for the irrigation water has also increased. Thus with the increase in demand-of food and fodder, demand of water for irrigation is also increasing. Also people preferred the crop which can give higher return i.e. sugarcane and other cash crops. They have also started taking crop in all seasons requiring the need of irrigation water throughout the year. Fortunately we are having sufficient quantity of water in the reservoir at Ukai to cater the need of existing demand of farmers. Problem is that of distribution system which was designed before 50 years for crop pattern and their requirement for water prevailing at that time. When the water requirement increased, the farmers at the tail end started facing problem as it is happening in most of the conventional distribution network.

ESTIMATION OF SEEPAGE LOSSES

In the present study, effect of crumb rubber as fine aggregate replacement on the compressive strength of concrete having mix proportions of 1:1.31:1.14 was investigated. The percentages of replacements were 0%, 10 %, 20% and30%by weight of fine aggregate. Tests were performed for compressive strength or all replacement levels of crumb rubber at different curing periods (7-days & 28-days).

Seepage from an irrigation canal is usually measured by following methods.

A) Direct measurement method
B) Indirect mesurment method

Direct method can not be used as prevailing site condition and dose not permit the same and hence, it is decided that the indirect method of finding the seepage by conducting the seepage analysis of the soil in the laboratory was performed.

B) Indirect mesurment method

1. Variable head test:

The variable head test is used for fine grained soils like silts and silty clays

The following formula is applicable:

$$k = 2.203\frac{a \times L}{A \times t}\log_{0}\left(\frac{h_1}{h_2}\right)$$

Where,

k = Coefficient of permeability at $T^{o}c.$ (cm/sec).
a = Cross Sectional area of stand pipe (cm²).
L = Length of soil specimen (cm)
A = Cross-sectional area of soil sample inside the mould (cm²).
t = ($t_1 - t_2$) = Time interval for the head to fall from h_1 to h_2.
h_1 = Initial head of water at time t_1 in the pipe, measured above the outlet.
h_2 = Final head of water at time t_2 in the pipe, measured above the outlet.

PROCEDURE

a) Preparation of remoulded soil specimen:

1. Weigh the required quantity of oven dried soil sample. Evenly sprinkle the calculated quantity of water corresponding to the OMC. Mix the soil sample thoroughly.
2. Clean the mould and apply a small portion of grease inside the mould and around the porous stones in the base plate. Weigh the mould and attach the collar to it. Fix the mould on the compaction base plate. Keep the apparatus on solid base.
3. The soil sample is placed inside the mould, and is compacted by the standard Proctor compaction tools, to achieve a dry density equal to the pre-determined MDD (Maximum Dry Density). Weigh the mould along with the compacted soil.
4. Saturate the porous stones. Place the filter papers on both ends of the soil specimen in the mould. Attach the mould with the drainage base and cap having saturated porous stones.

b) Saturation of soil specimen:

- Connect the water reservoir to the outlet at the bottom of the mould and allow the water to flow in the soil. Wait till the water has been able to travel up and saturate the sample. Allow about 1 cm depth of free water to collect on the top of the sample.
- Fill the remaining portion of cylinder with de-aired water without disturbing the surface of soil.
- Fix the cover plate over the collar and tighten the nuts in the rods
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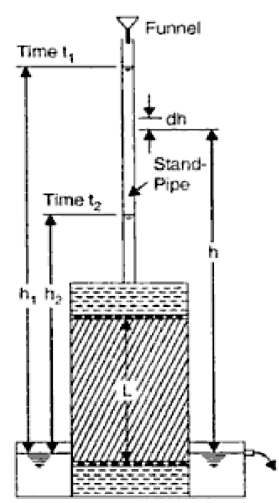

FALLING HEAD TEST.

2 . Davis and Wilson formula

These authors suggest the following formula for the estimation of seepage in lined and unlined canals

S = 0.45 · C · $h^{1/3}$ / (P.L/(4 · 10^6 + 3.65 · $V^{1/2}$))

where:

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S is the seepage, in $m^3/sec/m^2$ of wetted surface (perimeter) of the canal, h is the water depth, in meters, V is the flow velocity in the canal, in m/s, C is a numerical coefficient =3.5

3. Mortiz Formula (USSR)
S= 0.2 *C *(Q/V)^0.5

In which;
S: are the seepage losses in cubic foot per second per mile length of canal,
Q: is the discharge (ft3/sec),
V: is the mean velocity (ft/sec), and
C: is a constant value depending on soil type taken as o.34 for clay

4. Molesworth and Yennidunia (analytical equation)
Deduced analytical formulae to estimate seepage losses which are written as follows;

S = asQ

In which;

S : the seepage loss in m3/s/km;
R : the hydraulic radius.
i : the bed slope
as= 0.375*10^-4/(R^1.166*i^0.5) seepage loss factor m^-1

5. Pakistanian Formula
S=5.Q^0.0652.P.L/10^6

In which;
S : seepage losses;
Q : the discharge in ft3/sec,
P : the wetted perimeter of wetted section; and
L : length of channel in feet.

RESULT ANALYSIS
We can say that for $1m^3$ M20 grade of concrete consumption of fine aggregate is 775.96 kg. Here in specimen M-3 we replace fine aggregate by 24.62 kg of crumb rubber for $1m^3$M20 grades of concrete. So, we can say that up to 15% foundry sand utilized for economical and sustainable development of concrete. Uses of crumb rubber in concrete can reduce the harmfulness to the environment and produce a 'greener' concrete for construction. An innovative supplementary Construction Material is formed through this study.

TABLE- 2 THE RESULTS OF THE COMPUTED AVERAGE SEEPAGE LOSSES FOR K.R.B.M CANAL AT DIFFERENT CRITICAL SECTIONS BY VARIOUS FORMULA

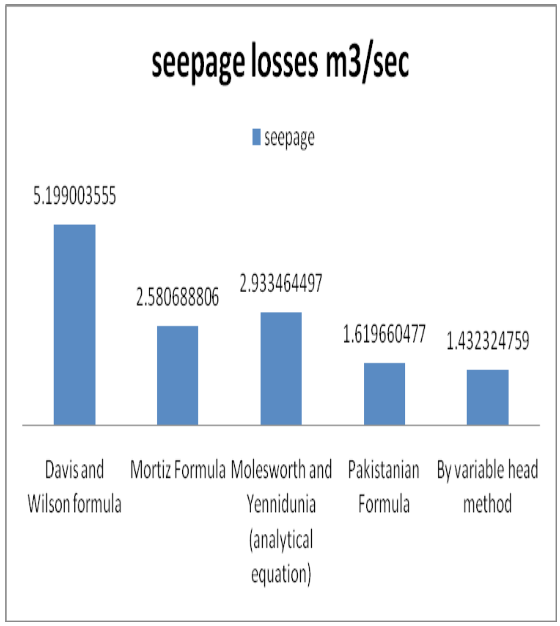

TABLE -3 COMPARISION SEEPAGE LOOSES BY DIFFERENT EMPHIRICAL FORMULA

CH(chainage)		RD(running distance)	Length in mt.	Davis and Wilson formula(m3/sec)	Mortiz Formula(m3/sec)	Molesworth and Yennidunia (analytical equation) (m3/sec)	Pakistanian Formula(m3/sec)	By variable head method(m3/sec)
0	16357	53.65096	16357	2.55015	0.66714	0.8243	0.49785	0.25437
16357	25201	82.65928	8844	0.55462	0.38873	0.40734	0.2308	0.25759
25201	28040	91.9712	2839	0.06118	0.12066	0.13765	0.07716	0.10028
28040	42988	141.0006	14948	1.66529	0.63224	0.71961	0.40235	0.42691
42988	46795	153.4876	3807	0.10277	0.16299	0.17535	0.09935	0.13953
46795	52280	171.4784	5485	0.15845	0.2299	0.28412	0.12702	0.08865
52280	56093	183.985	3813	0.07012	0.16141	0.18591	0.08387	0.06499
56093	57813	189.6266	1720	0.0132	0.07795	0.06969	0.0353	0.04126
57813	59293	194.481	1480	0.00933	0.06689	0.05905	0.02964	0.0252
59293	60980	200.0144	1687	0.01389	0.07278	0.07045	0.03632	0.03354
			Total seepage losses=	5.199004	2.580689	2.933464	1.61966	1.432325

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CONCLUSION

The Seepage losses of K.R.B.M.C were computed by emphirical formula at different sections along the total length of canal. The main conclusions can be summarized as follows:

1. Tha minimum seepage loss occurred at 190 to 194 RD and maximum seepage losses occurred at section 91 RD and 171RD.
2. The result of computed seepage losses by emphirical formula of variable head method and pakistanian formula give good result.
3. We advise using variable head method and pakistanian emphirical formula for computing seepage losses in canal of K.R.B.M.C.

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