Empirical Observation based Seepage Analysis of Madhya Ganga Canal

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Abstract— Seepage and evaporation are the most serious forms of water losses in an irrigation canal network. Seepage loss depends on the channel geometry, whereas evaporation loss is proportional to the area of the free surface. The conservation of water is becoming increasingly important as the demand for this vital natural resource continues to rise rapidly and new sources of supply become scarcer. The importance of lining irrigation channels with the view to save these losses cannot be over emphasized. In this paper seepage rate for the Madhya Ganga canal phase-2 at Bijnor District of Uttar Pradesh, India is calculated by the empirical formula and USBR formula and is presented in this paper.

Key words: USBR, LDPE, HDPE, EPDM

I. INTRODUCTION

Canal are major source for supplying surface water for irrigation particularly in Indian sub-continent. They reduces the shortage of water due to lesser rainfall days, which leads to low recharge in the area. Canal are very effective to reduce the agricultural water demand in an area. Canals can carry water easily from source to the destination. However canals can lose its water between 10-40% due to losses. Hence canal lining is required to reduce these losses.

Mainly seepage loss and evaporation loss are the most severe forms of losses in a canal network. Seepage rate is mainly controlled by channel geometry, effective hydraulic continuity of an underline base material and conveyance material, and the hydraulic gradient, whereas losses due to evaporation is directly proportional to the free surface area. Lining reduces seepage from canals. Basic linings consists of use of PVC, HDPE, LDPE, and EPDM Geomembrane.

II. STUDY SITE

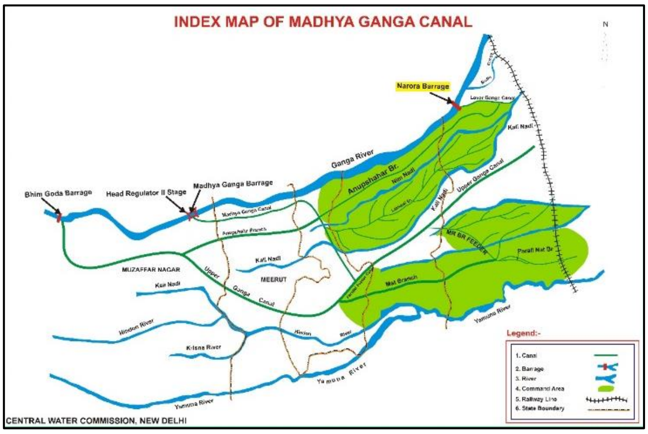

Fig. 1: Index Map of Madhya Ganga Canal, Bijnor, Uttar Pradesh, India

Madhya Ganga Canal, Phase -2 start from the Head Diversion work at Bijnor District of Uttar Pradesh, India. Study Site has Longitude: $78^{0}2'2''$(E) and Latitude: $29^{0}22'27''$(N) and a mixture of sandy and Alluvial soil has been found on our project site, which has high potential of Seepage. Hence to reduce the seepage losses canal lining is implemented. According to IS:4745-1968, the expected seepage losses from hard surface lined canals are assumed as 0.60 m^3/s/million m^2 of wetted perimeter, which is equivalent to about 0.05 m^3/day/m^2 of wetted perimeter.

III. BENEFITS OF CANAL LINING IN MADHYA GANGA CANAL

Cement concrete lining made from M15 cement concrete mix (1:2:4) is considered a good quality type of lining. Such lining usually give very satisfactory service and are widely used owing to their durability, impermeability, hydraulic efficiency, and for providing weed free surface. Despite the fact that initial cost of C.C. lining is high, yet it has long life and low maintenance cost usually makes it economical over the life span. Average Life of Cement concrete lining is considered to be 75 years.

Certain benefits of canal lining are described as below:

- Reduction in seepage Losses.
- Increasing the yield of the crop with proper irrigation
- Water conservation.
- Control of water logging.
- Reduced maintenance of the canal
- Lining doesn't permits weed growth and hence lowering in transpiration losses.

Fig. 2: Madhya Ganga Barrage, Bijnor, Uttar Pradesh, India.

IV. METHODOLOGY

Preparation of subgrade is the very first step in any canal lining process it encompasses of removal of Loose Soil From the surface followed by provide proper compaction to minimum depth of one foot below the final grade, measured perpendicular to the surfaces of the canal prism.

Selection of the shape of cross section is considered crucial and among all types, trapezoidal channel is considered to be hydraulically efficient channel. Due to ease of cutting and constructing and also providing maximum wetted perimeter this type of channel have been mostly preferred. Longitudinal slope of channel is generally influenced by the topography, purpose of canal and the head required to convey design flow. The slopes adopted in the irrigation channel should be as minimum as possible in order to irrigate the highest command and it is generally varies from 1: 4000 to 1: 20000. As per the data acquired from Uttar Pradesh Irrigation department the longitudinal slope in phase -2 is 1:8000 i.e.0.125m/Km, Side slope of the embankment is 1.5:1 and the thickness of 7.5-10 cm is found out to be suitably enough to reduce the seepage loss in the canal. For discharge value of 128 cumecs this value of thickness of slab falls under the safe guidance of Indian Standard Code 3873-1993.

The slab of size 3000x3000 mm is casted on the prepared subgrade of soil at the site of construction. Shuttering is done between the slabs with the help of wooden frame or foam work. Wooden frames are commonly used due to locally availability of the material. Construction joints serves as contraction joints in the canal to overcome expansion and contraction die to the temperature variation caused in the slab. Permissible Velocities (Minimum and maximum) are also taken into consideration, which is refer to the minimum velocity at which both vegetative growth and sedimentation is avoided. Average velocity of (0.60 to 0.90 m/s) prevents from sedimentation, generally velocity of 0.75 m /s is usually considered sufficient.

Freeboard is also provided at the time of design of the canal. It is refers to the vertical distance between top of the channel carrying the design flow at normal depth. The purpose of freeboard is to prevent the overtopping of water in the canal. As per the Indian Standard Code 4745 – 1968 and Indian Standard Code 7112 – 1973 freeboard is taken as 0.9 m for discharge above 85 cumecs. There is provision of providing curing drain so that cement can gain its maximum strength which usually occurs in 28 days, after the purpose of curing drain is fulfilled it is covered with earth fill to serves as embankment in the side of the canal banks. The rate of flow is inversely proportional to the *surface roughness*. The surface roughness is measured by Manning's coefficient (n) for designing of several types of canal lining.

A. *Manning's Roughness Coefficient (n) calculation*

$$Q= (1/n)\ R^{\wedge 2/3}\ S^{1/2}$$

Where,

Q=discharge in m^3/sec
Area (A) = (b +my) y
Hydraulic Radius (R) = A/P
Wetted perimeter (P) =B+2y $(m^2+1)^{1/2}$
As, Side slope (m) =1.5, Breath (B) = 27meter
A=3.45(27+1.5X3.45)
A=111m^2
P=$27+2(1.5^2+1)^{1/2}3.45$
P=34.439m
R=111/34.439m
R=2.81m
Putting these values in Manning's equation

$$Q= (1/n)\ R^{\wedge 2/3}\ S^{1/2}$$

$128= (1/n)\ (2.81)^{2/3}(1.5)^{1/2}$
n=0.019053

B. *Estimation of seepage loss*

Seepage is estimated by the empirical formulae Adopted at study site (Bijnor, Uttar Pradesh) and it is also computed by the USBR formula for seepage loss.

In the Uttar Pradesh State, the empirical formula is utilized for the estimation of seepage losses in unlined canal.

$$S = C\ (b + h)^{2/3} / 200\ m^3/sec/km$$

Where

- S is the seepage losses, in m^3/s per kilometer length of canal,
- b is the bed width of the canal, in meters,
- h is the depth of the flow, in meters.

From	To	L (Km)	Q (m^3/sec)	B	S_o (m/Km)	h	P	A	V	C	Seepage m^3/sec/Km
0.0	16.32	16.32	147	27.0	0.125	3.45	39.42	111.0	1.32	0.41	0.048
16.32	22.08	5.76	138.5	27.0	0.125	3.40	39.24	109.14	1.30	0.41	0.0487
22.08	27.42	5.34	128.2	26.7	0.125	3.28	38.50	103.72	1.23	0.41	0.0482
27.42	35.48	8.01	114.8	26.3	0.125	3.15	37.64	97.13	1.16	0.41	0.0476
35.48	41.60	6.12	100.5	25.0	0.125	3.10	36.16	91.92	1.09	0.41	0.0460
41.60	44.10	2.50	93.2	25.0	0.125	3.10	36.16	91.92	1.01	0.41	0.0460
44.20	56.15	11.95	75.7	24.8	0.125	3	35.6	87.9	0.86	0.41	0.0458
56.15	66.20	10.85	60	24.8	0.125	2.93	34.84	84.0	0.71	0.41	0.0454

Table 1: Seepage Calculation Using empirical U.P. Formula = $(b + h)^{2/3}$ /200 m^3/sec/km

From	To	L (Km)	Q (m^3/sec)	B	S_o (m/Km)	h	P	A	V	C	Seepage m^3/sec/Km	Seepage m^3/sec
0.0	16.32	16.32	147	27.0	0.125	3.45	39.42	111.0	1.32	0.41	0.052	0.86
16.32	22.08	5.76	138.5	27.0	0.125	3.40	39.24	109.14	1.30	0.41	0.147	0.85
22.08	27.42	5.34	128.2	26.7	0.125	3.28	38.50	103.72	1.23	0.41	0.155	0.85
27.42	35.48	8.01	114.8	26.3	0.125	3.15	37.64	97.13	1.16	0.41	0.100	0.81
35.48	41.60	6.12	100.5	25.0	0.125	3.10	36.16	91.92	1.09	0.41	0.127	0.78
41.60	44.10	2.50	93.2	25.0	0.125	3.10	36.16	91.92	1.01	0.41	0.312	0.78
44.20	56.15	11.95	75.7	24.8	0.125	3	35.6	87.9	0.86	0.41	0.06	0.76
56.15	66.20	10.85	60	24.8	0.125	2.93	34.84	84.0	0.71	0.41	0.07	0.75

Table 2: Seepage Calculation Using USBR Method = 0.2 *C *$A^{1/2}$

V. CONCLUSIONS

Seepage Rate calculated for the unlined canal can be reduced by canal lining. Hence a cement concrete lining of M15 grade was found suitable to reduce this seepage. Canal Lining Work proposed by Uttar Pradesh Irrigation Department at Madhya Ganga Phase -2, Bijnor was found effective to prevent this seepage rate. Hence, huge amount of water can be saved by this project which will irrigate more command area.

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