SEEPAGE FROM EARTH EMBANKMENT WITH UPSTREAM BLANKET TO A VERTICAL CRACK EXTENDING TO THE IMPERVIOUS LAYER

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ABSTRACT

The problem studied in this paper represents seepage from earth embankment at the end of a canal to a vertical wide crack or deep drain lies at near distance from this canal. To minimize seepage as possible, an impervious upstream blanket is used. An experimental study is carried out to investigate the effects of length of the upstream blanket (ℓ), depth of the impervious layer measured from canal bed level (d) and the water depth in the canal (H) on both seepage discharge (q) and loss of head due to blanket (h). The other dimensions of the earth embankment are kept constant.

NOTATION

- a half inner distance between the two prespex plates,
- d depth of the impervious layer measured from canal bottom,
- g acceleration due to gravity,
- h loss of head due to upstream blanket,
- H The water depth in the canal.
- K hydraulic conductivity of the soil = $\frac{a^2 . g}{3\nu}$,
- ℓ horizontal length of the blanket,
- L drain distance measured from the heal of embankment, 73 cm
- q seepage discharge,
- α angle of inclination of the upstream face of embankment = 45°, and
- υ kinematic viscosity of the oil used in the experiments.

INTRODUCTION

Seepage from earth embankment with upstream blanket to a vertical crack or deep drain extending to the impervious layer is studied experimentally. The problem studied herein can be considered equivalent to that seepage from earth dam with upstream blanket or trapezoidal canal of infinite bed width into a vertical drain. The blanket in each case of both earth dam and canal is used to minimize seepage discharge passed to the vertical drain.

Solutions for seepage from trapezoidal channels to drainage layers at infinite or finite depths were presented by Vedernikov [4]. Also Vedernikov [10] solved the problem of seepage from a dam resting on soil of the same permeability extending to infinite depths into a horizontal drain located at some distance within the dam.

A study of the theoretical effect of depth and shape of the channel and position of the ground-water table on seepage from canals was made by Bouwer [7]. He also considered effect of sealing canal bottom on seepage to reduce it, where for wide, shallow canals, most of the seepage occurs at bottom. Garg and Chawla [2] obtained a closed-form solution of seepage from a trapezoidal channel in homogeneous and isotropic material extending to infinite depth with horizontal or vertical drainage at a finite distance from the canal.

Dachler [1] presented an approximate treatment concerning shallow water tables in which both model experiment and an approximate analysis were combined. He derived a procedure for computing the seepage from a trapezoidal channel overlying an impervious layer to a fully penetrating vertical drain at some distance away from the channel.

A closed-form solution of the problem of seepage from a canal in a homogeneous medium extending to finite depth to drains located a finite distance from the canal considering vertical and horizontal drainage was presented by Sharma and Chawla [6]. Hathoot [5] studied the problem of seepage from a single canal into a semi permeable clay layer. Based on hydrodynamic theory he established the seepage discharge formula which has similar characteristics to the equation given by Hammad [3].

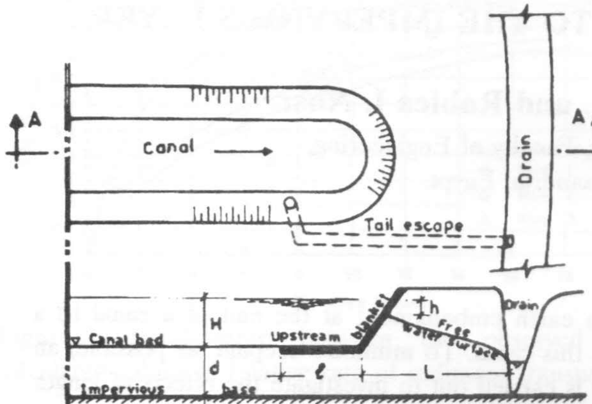

Figure 1. Geological section A-A.

EXPERIMENTAL SET-UP

The problem of seepage from canal to a vertical drain is studied experimentally using a Hel-Shaw model which is shown in Figure (2). The model is consists of two prespex plates 1160 * 420 * 10 mm. As mentioned before to minimize seepage from canal, blanket (7) is used with different lengths. The interspace between the two prespex plates is kept 1.5 mm using a klingarite washers. Also a horizontal strips of the same klingarite (8) are used to change the depth of the impervious layer from canal bottom. The vertical drain near the canal has a constant distance and is represented by a vertical channel (9).

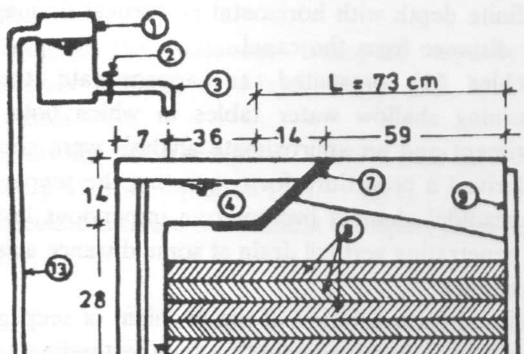

Figure 2. Experimental set-up.

A graduated vessel (10) is used to collect and measure seepage discharge. Each of the feeder tank (4) and (5) receives oil (super 7500-20w/B) from the main supply tank (1) through a pipe (3). Oil is controlled by a valve (2). The overflow tube (6) is used to keep a constant head in the feeder tank and to discharges excess oil to the collecting tank (11). A centrifugal pump (12) lifts the oil from the collecting tank to the main supply tank through the pipe (13).

PROCEDURE OF EXPERIMENTS

The procedure of the experiments, for the problem studied herein, is carried out as follows:

1. For constant values of the depth of the impervious base from canal bottom (d) and length of the blanket (ℓ), the depth of water (H) is changed five times; 4,6,8,10 and 12 cm. For each value of H, both of seepage discharge (q) and loss of head due to blanket (h) is measured.
2. For the same constant value of (d), the length of the blanket (ℓ) is changed several times and both of seepage discharge (q) and the loss of head due to blanket (h) are measured.
3. The above procedure is repeated for five values of (d); 1,2,4,8 and 12 cm.
4. Free water surface is recorded experimentally in each case.
5. Drain distance (L) remains constant for all experiments.

ANALYSIS OF RESULTS

The main parameters studied experimentally in this paper are the effect of length of the blanket and the effect of the depth of the impervious layer measured from canal bottom on both seepage discharge and loss of head due to blanket.

Figure (3-a) shows the effect of the blanket length (ℓ/H) on loss of head (h/H) for constant values of $d/L = 0.014$ and $H/d = 12$. The figure indicates that loss of head increases with increasing length of the blanket. The corresponding seepage discharge, as shown in Figure (3-b), decreases with increasing length of the blanket.

The effect of the vertical distance of the impervious layer (d/H) is shown in Figure (4-a and 4-b). Increasing the depth of the impervious layer increases the seepage discharge passing to the vertical drain for constant values of $\ell/L = 0.11$ and $H/\ell = 1.5$, while the loss of head decreases. The above relationships are given in Tables 1 and 2.

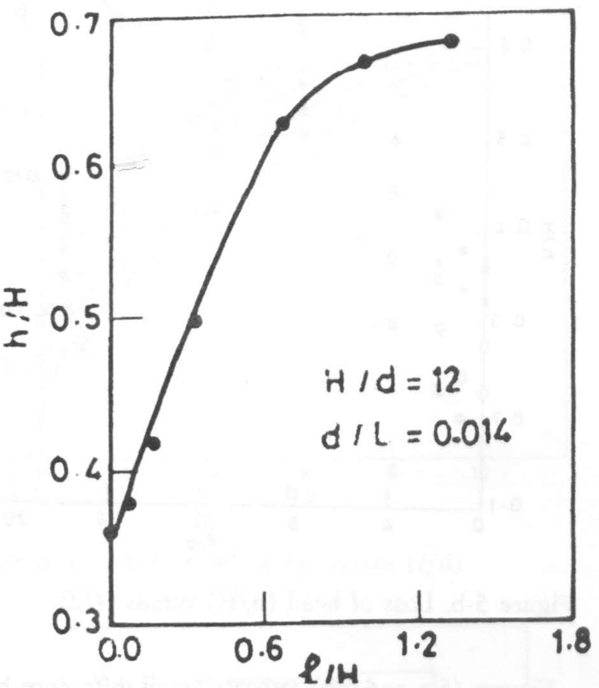

Figure 3-a. Length of blanket versus loss of head.

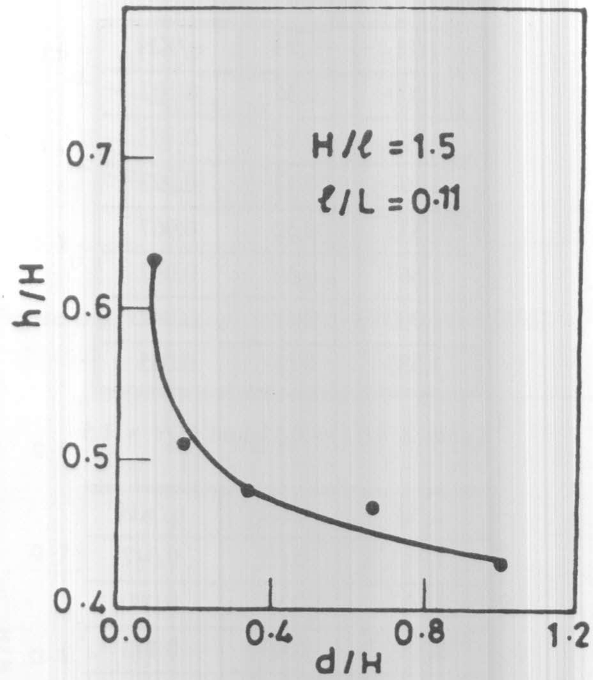

Figure 4-a. Depth of the impervious layer versus loss head.

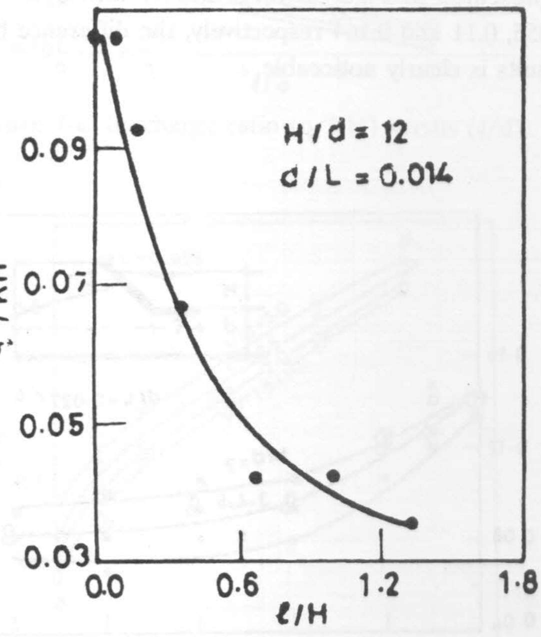

Figure 3-b. Length of blanket versus seepage discharge.

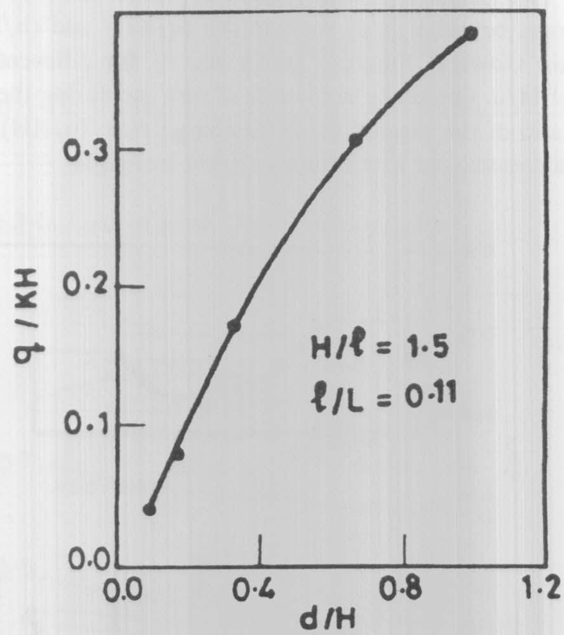

Figure 4-b. Depth of the impervious layer versus seepage discharge.

Table 1. d/L = 0.014 and H/d = 12

ℓ/H	h/H	q/KH
0.000	0.36	0.107
0.083	0.38	0.107
0.167	0.42	0.093
0.333	0.50	0.067
0.667	0.63	0.042
1.000	0.67	0.042
1.333	0.68	0.035

Table 2. ℓ/L = 0.11 and H/ℓ = 1.5

d/H	h/H	q/KH
0.083	0.63	0.042
0.167	0.51	0.080
0.333	0.48	0.173
0.667	0.47	0.312
1.000	0.43	0.387

Five groups of design charts are plotted in dimensionless form between (ℓ/d) versus both (q/KH) and (h/H) and are shown in Figures (5,6,7,8 and 9), for different values of H/d. Generally noticed that with increasing the length ratio of the blanket (ℓ/d), discharge ratio (q/KH) decreases and loss of head (h/H) increases.

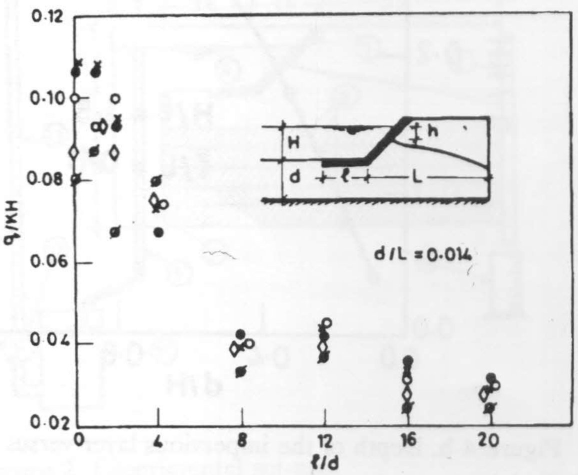

Figure 5-a. Discharge ratio (q/KH) versus (ℓ/d).

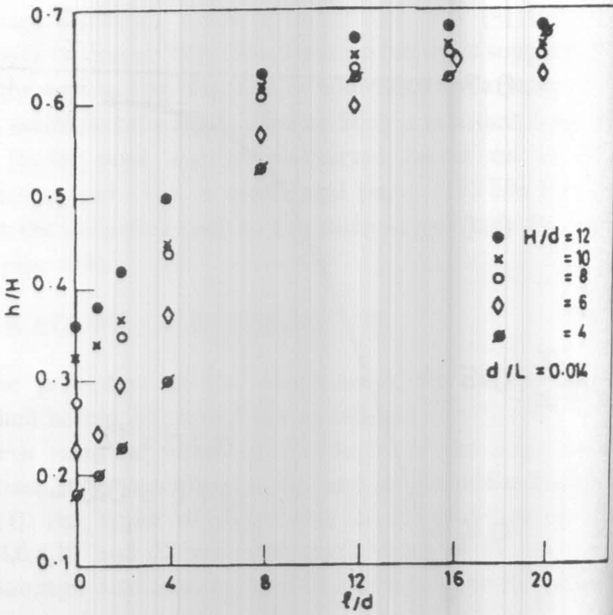

Figure 5-b. Loss of head (h/H) versus (ℓ/d).

Figures (5-a and 5-b) indicate small difference between the experimental points, this is due to the small value of d/L which is used in this group of experiments; d/L = 0.014. However in other groups of experiments, which are represented in Figures (6,7,8 and 9) with d/L = 0.027, 0.055, 0.11 and 0.164 respectively, the difference between results is clearly noticeable.

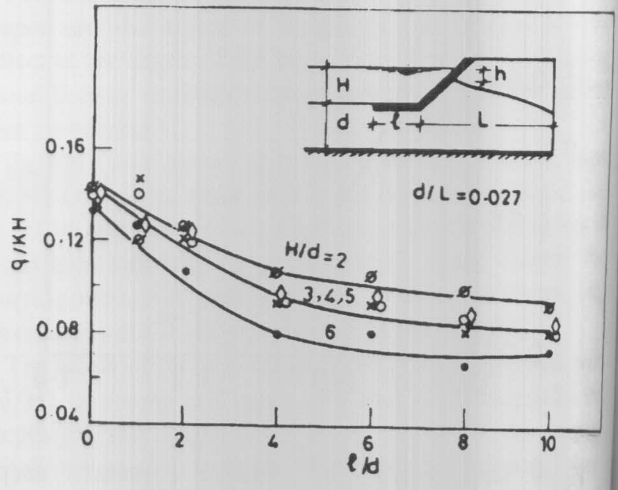

Figure 6-a. Discharge ratio (/kH) versus (ℓ/d).

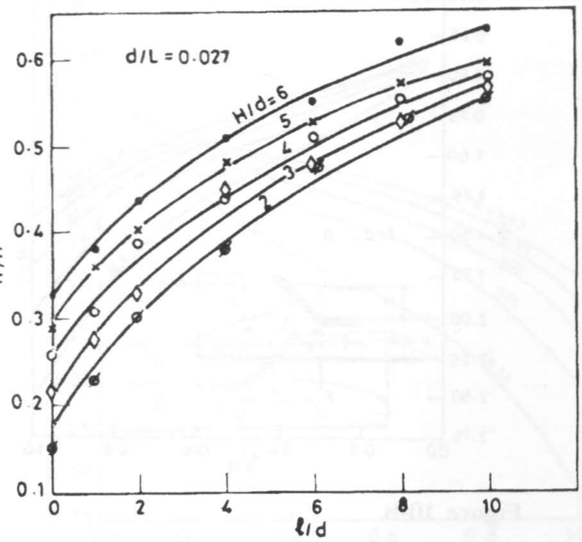

Figure 6-b. Loss of head (h/H) versus (ℓ/d).

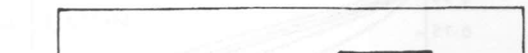

Figure 7-a. Discharge ratio (q/KH) versus (ℓ/d).

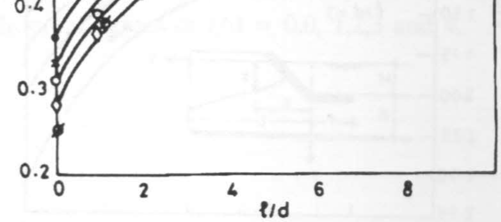

Figure 7-b. Loss of head (h/H) versus (ℓ/d).

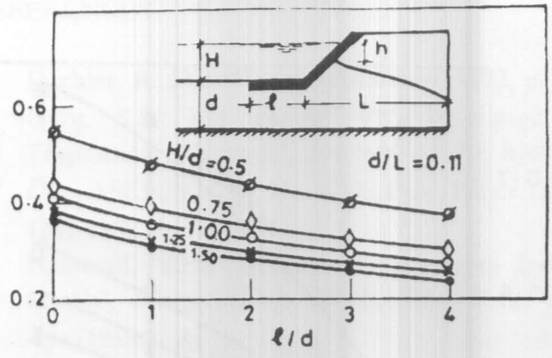

Figure 8-a. Discharge ratio (q/KH) versus (ℓ/d).

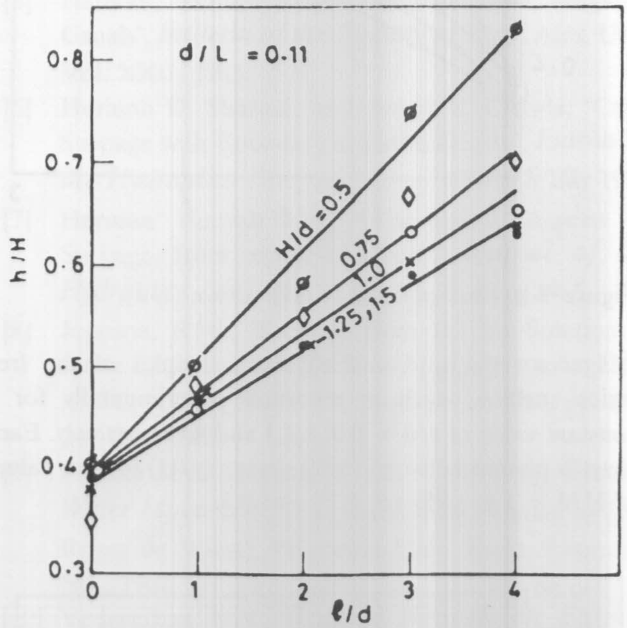

Figure 8-b. Loss of head (h/H) versus (ℓ/d).

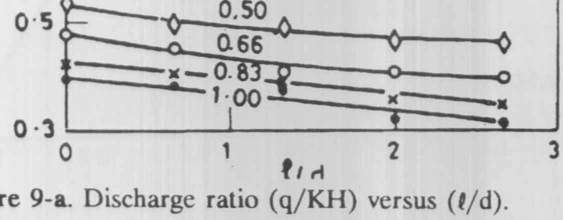

Figure 9-a. Discharge ratio (q/KH) versus (ℓ/d).

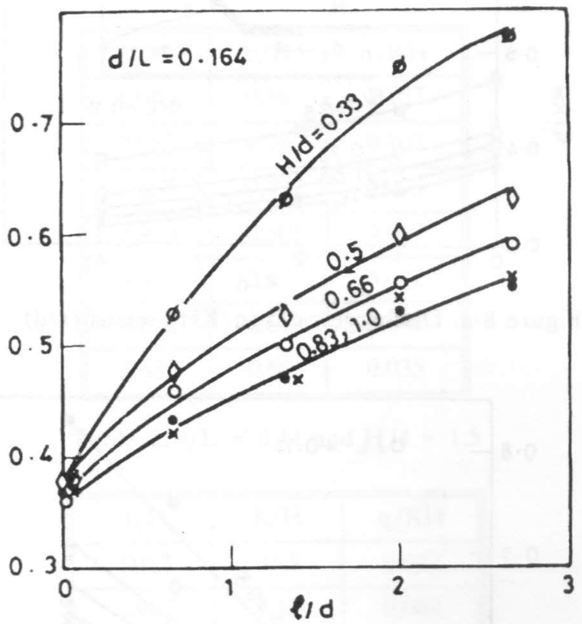

Figure 9-b. Loss of head (h/H) versus (ℓ/d).

Figures (10-a,b,c,d and e) show samples of the free water surface which is recorded experimentally for a constant value of ℓ/d = 0.0, 1,2,3 and 4 respectively. Each chart is plotted between (x/L) versus (y/H) for five values of H/d = 1.5, 1.25, 1.0, 0.75 and 0.5.

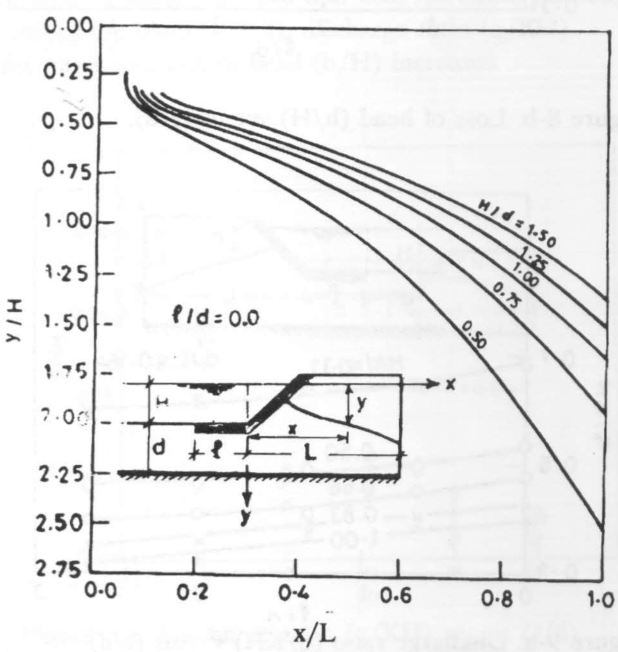

Figure 10-a.

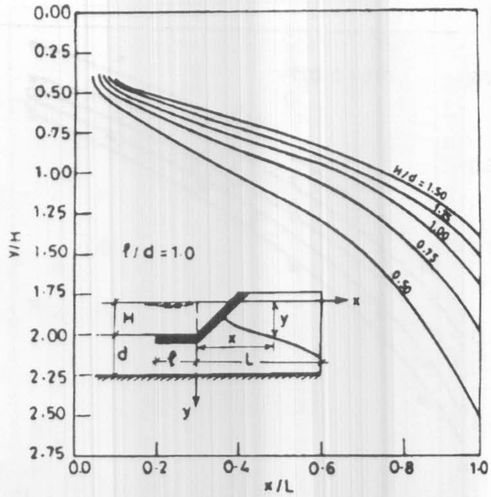

Figure 10-b.

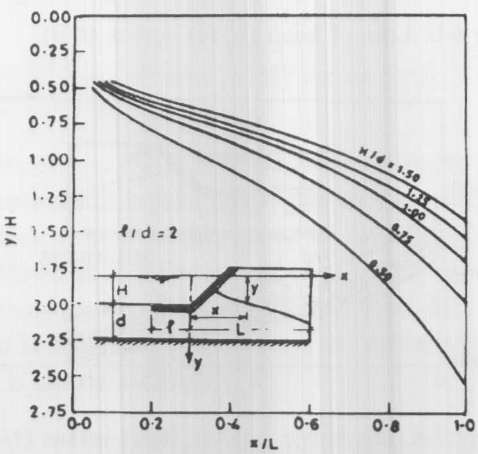

Figure 10-c.

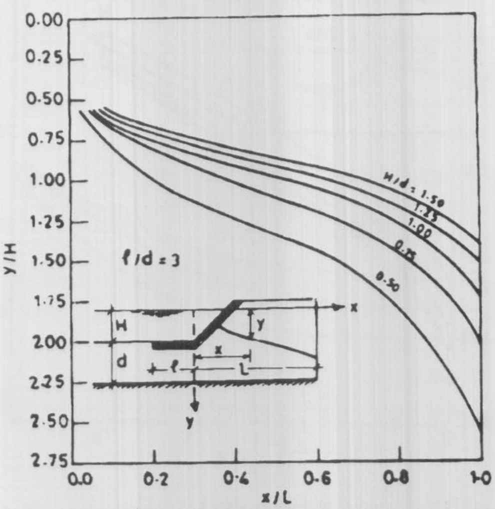

Figure 10-d.

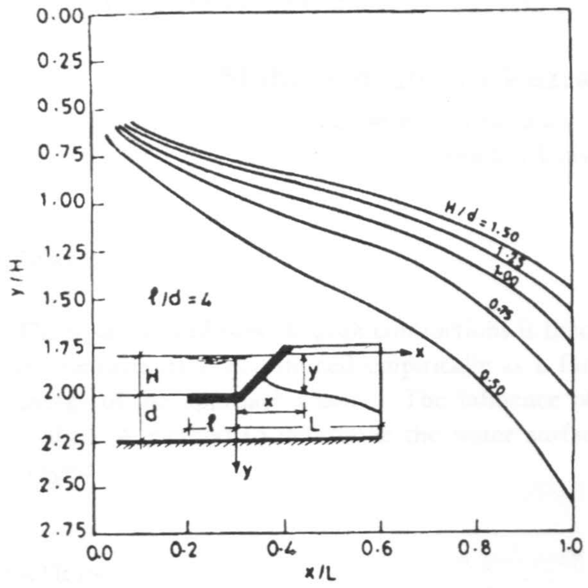

Figure 10-e.

CONCLUSION

Seepage through an earth embankment with upstream blanket to a vertical drain extending to the impervious layer is studied experimentally and the following conclusions are made:

Effect of both length of the upstream blanket and the depth of the impervious layer measured from canal bottom is studied on both seepage discharge passing to the vertical drain and loss of head due to blanket. It is found that seepage discharge decreases with increasing length of the blanket, while loss of head increases. It is also noticed that seepage discharge increases with increasing the depth of the impervious layer and loss of head decreases. Five groups of the design charts are plotted between (ℓ/d) and both of (q/KH) and (h/H) for values of H/d ranging from 0.33 to 12 and ford/L ranges from 0.014 to 0.164. Also a sample of the free water surface, which is recorded experimentally, is shown in dimensionless form; (x/L) versus (y/H), for H/d = 1.5, 1.25, 1.0, 0.75 and 0.5 and for different values of ℓ/d = 0.0, 1,2,3 and 4.

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