Seepage Analysis using Drainage Seepage Tank

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Abstract - *Seepage in soil engineering is movement of water through the soils, often a critical problem in building foundations. Seepage in ground water is dependent on many factors like Permeability of the soil, Pressure gradient, and also, between the combination of forces that acts on the water through gravity and other natural factors. Permeability may vary over a wide range, depending upon structure of soil, its composition, making possible the safe design of such structures as earth dams and reservoirs with a very low (negligible) leakage loss and other structures such as roadbeds and filtration beds in which rapid drainage is desirable. Hydraulic structures are very severely affected by the ground water seepage.*

Key Words: **Seepage Analysis, Permeability, Pressure Gradient, Drainage Seepage Tank, Height Gradient**

1.INTRODUCTION

Seepage is slower movement of fluid or gas through pores or small holes in the structure. It may be seen in many civil structures but when we consider dams, canals, reservoirs seepage pressure throws an upward push to the structure and reduces the effective stress of within soil. If the seepage pressure is large enough, Soil below the foundation will be eroded and gets deposited at the end resulting a big void below the foundation leading it to collapse.
Analysis can be performed using Drainage-Seepage Tank where we can change the dimensions, Pressure, Heads, Flow rate and can analyses the Seepage pressure.

1.1 DRAINAGE-SEEPEAGE TANK

The tank consists of a big sand tank separated through a sheet pipe and have a thin permeable sheet at the end. The advantage of using the tank is that it has adjustable height and width of the sand tank and heads.

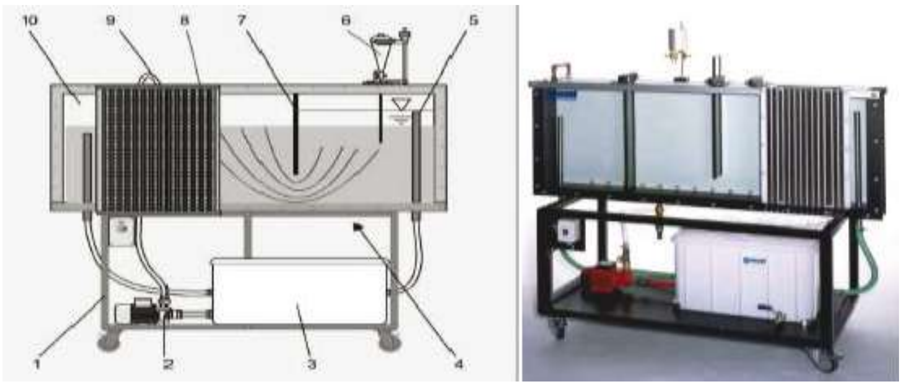

Figure 1: Drainage Seepage Tank

1. Stand	6. Dye Injection System
2. Submersible pump	7. Splitter
3. Lower water tank	8. Piezometer
4. Sand tank	9. Pressure head column
5. Head Column	10. Sump tank (Side water tank)

2. METHODOLOGY

- The process of analysis starts with the cleaning of the tank and filling it with water and sand at Lower water tank and sand tank respectively.

- There after forming a structure (Mountain like) with different slopes for different readings.
- Then allow the water to flow from the porous material (i.e., Sand).
- Adjust the height heads and allow a steady flow of water.
- Place the tip of the dye injection at different points.
- Allow the water and ink to flow and to form a pattern inside the structure.
- Take the pictures and readings of the pattern flow and heights
- And thus, can draw equipotential lines.

3. FORMULAE USED

$$Q = \frac{K*A(\Delta h)}{\Delta l}$$

Where, Q is discharge (m^3/sec), A is Area of cross section (m^2), Δh is Head difference, Δl is length of the path flow, **K is permeability Coefficient (m/sec)**

Hydraulic Gradient (i) =
$i = \frac{\Delta h}{\Delta l}$ Where, Δh is Head difference, Δl is length of the path flow

And some other basic **trigonometric formulas**.

4. ASSUMPTIONS

Following are the assumptions to be consider while performing the analysis:

- ✓ Darcy's law is valid. (laminar flow)
- ✓ The soil is completely saturated.
- ✓ The soil is Homogenous.
- ✓ The soil is isotropic.
- ✓ During the flow, we assume that volume of soil and amount of water remains constant.
- ✓ The soil and water are incompressible.

5. OBSERVATION AND CALCULATIONS

5.1 READING-1

Here we have made an angle of slope as 20^0 with the axis plane (ground). The two-height adjusted at H_1 and H_2 respectively. The Horizontal distance of ink points of first line is 5cm and second line is 17cm. The vertical distance of ink points of first line is 28cm and second line is 31 cm, so as to get a distinct visibility of the flow of the dye. Let the difference in the ink points be ΔL. So as to get a distinct visibility of the flow of the dye. Let the difference in the ink points be ΔL.

Figure2: Experimental Setup for Reading-1

5.1.1. Calculations: Let the height H_1 be 32cm and H_2 be 26cm

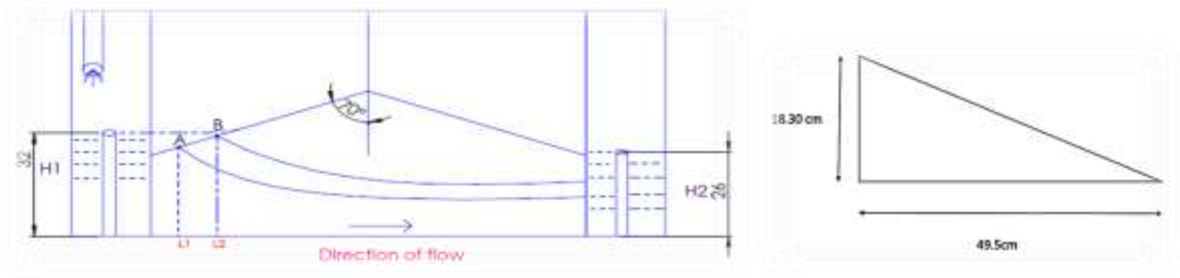

Figure 3: Solidworks Drawing of Reading-1

$\tan \varnothing = \frac{18.30}{49.5}, \varnothing = 20°$

So, the difference in height $\Delta H = H_1 - H_2 = 32 - 26 = 6cm =$ **0.06m**

Width of the tank =12cm =**0.12m**

The difference in ink points $\Delta L = (L_2 - L_1) = 17 - 5$ cm=12cm=**0.12m**

Q=**0.3*10^-6^ m^3^/sec**

Area = height of trapezoid * width $= \frac{(31*0.12+28*0.12)*}{2} *10^{-2} =$ **$3.54*10^{-2}m^2$**

$i = \frac{\Delta h}{\Delta l} = \frac{6}{12} = 0.5$

$K = \frac{Q*\Delta L}{A*\Delta H} = \frac{(0.3*10^{-6}*0.12)}{3.54*10^{-2}*6*10^{-2}}$ **$=0.1694*10^{-4}m/sec$**

At pressure,

P1 =10cm P4=3.7cm

P2 =6cm P5=1.6cm

P3=4.4cm P6=2.5cm

Points taken 14cm apart.

Therefore, the coefficient of permeability comes to be **$0.169*10^{-4}m/sec$** by the use of Darcy's Law.

5.2 READING-2

Here we have made an angle of slope as 25^0 with the axis plane (ground). The two-height adjusted at H_1 and H_2 respectively. The Horizontal distance of ink points of first line is 9.5cm and second line is 26cm. The vertical distance of ink points of first line is 26.5cm and second line is 37cm respectively so as to get a distinct visibility of the flow of the dye. Let the difference in the ink points be ΔL.

Figure 4: Experimental Setup for Reading-3

5.2.1. Calculations: Let the height H_1 be 38.5cm and H_2 be 28.5 cm

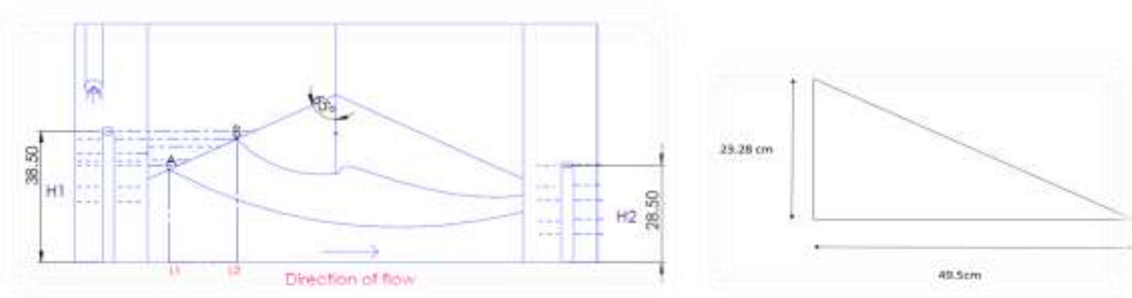

Figure 5: Solidworks Drawing of Reading-2

$\tan \varnothing = \frac{23.28}{49.5}, \varnothing = 25°$

So, the difference in height $\Delta H = H_1 - H_2$ =38.5 – 28.5 =10cm = **0.1m**

Width of the tank=12cm = 0.12m

The difference in ink points $\Delta L = (L_2 - L_1)$ =26 – 9.5 =16.5cm =**0.165m**

Q=**$0.3*10^{-6}$ m³/sec**

Area (avg.) $= \frac{(37*0.12+26.5*0.12)*}{2} *10^{-2}$ =**$3.81*10^{-2}$m²**

$i = \frac{\Delta h}{\Delta l} = \frac{10}{16.5} = 0.60$

$K = \frac{Q*\Delta L}{A*\Delta H} = \frac{(0.3*10^{-6}*0.165)}{0.1*3.81*10^{-2}}$ =$12.99*10^{-6}$m/sec =**$0.129*10^{-4}$m/sec**

At pressure

P1 =24.5cm P4=16.8cm

P2 =20.5cm P5=10.0cm

P3=17.5cm P6=12.5cm

Points are taken 14cm apart.

Therefore, the coefficient of permeability comes to be **$0.129*10^{-4}$m/sec** by the use of Darcy's Law.

5.3 READING-3

Here we have made an angle of slope as 30^0 with the axis plane (ground). The two-height adjusted at H_1 and H_2 respectively. The Horizontal distance of ink points of first line is 8cm and second line is 28cm. The vertical distance of ink points of first line is 24cm and second line is 36cm respectively so as to get a distinct visibility of the flow of the dye. Let the difference in the ink points be ΔL.

Figure 6: Experimental Setup for Reading-3

5.3.1. Calculations: Let the height H_1 be 40cm and H_2 be 35cm

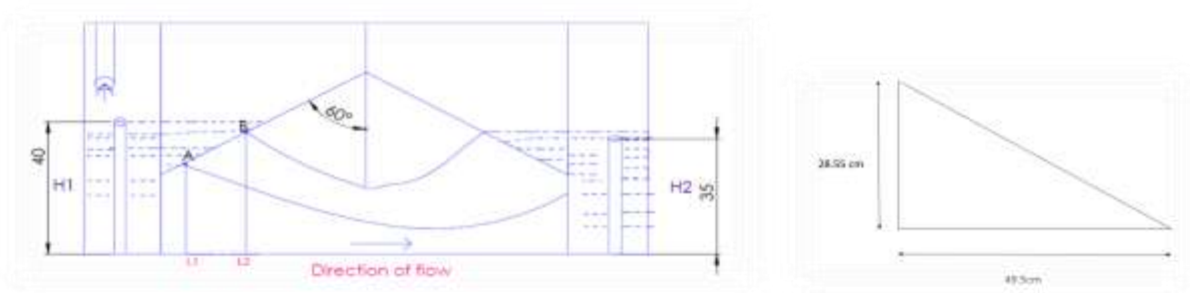

Figure 7: Solidworks Drawing of Reading-3

$\tan\varnothing = \frac{28.55}{49.5}, \varnothing = 30°$

So, the difference in height $\Delta H = H_1 - H_2 = 40 - 35 = 5cm$ = **0.05m**

Width of the tank=12cm **= 0.12m**

The difference in ink points $\Delta L = (L_2 - L_1) = 28 - 8 = 20cm$ =**0.2m**

Q=**$0.3*10^{-6}$ m^3/sec**

Area (avg.)$= \frac{(36*0.12+24*0.12)*}{2} *10^{-2} = 3.6*10^{-2}$ =**$3.6*10^{-2} m^2$**

$i = \frac{\Delta h}{\Delta l} = \frac{5}{20} = 0.25$

$K = \frac{Q*\Delta L}{A*\Delta H} = \frac{(0.3*10^{-6}*0.20)}{0.15*3.6*10^{-2}}$ $=12.11*10^{-6}$m/sec=**$0.121*10^{-4}$m/sec**

At pressure

P1 =31.5cm P4=23cm

P2 =34.8cm P5=20.3cm

P3=27cm P6=25.5cm

Points are taken 14cm apart.

Therefore, the coefficient of permeability comes to be **0.121*10^{-4}m/sec** by the use of Darcy's Law.

6. RESULT AND ANALYSIS

Table 1: Observation Table

S no.	$H_{1(m)}$	$H_{2(m)}$	ΔH	$L_{1(m)}$	$L_{2(m)}$	ΔL	i	⌀	A(10^{-2} m^2)	Q(10^{-6} m^3/sec)	**K(10^{-4} m/sec)**
1.	32	26	6	17	12	5	0.5	20	3.54	0.3	0.169
2.	38.5	28.5	10	26	9.5	16.5	0.6	25	3.81	0.3	0.129
3.	40	35	5	28	8	20	0.25	30	3.60	0.3	0.121

7. USE FOR SEEPAGE ANALYSIS

- **Calculation of seepage losses from reservoirs and canals:** We can calculate the flow underneath the dam using the flow net in the transformed space.
- **Determining uplift pressures below/underneath dams:** Using flow net, it is possible to determine the pressure head at any point at the base of the dam. The uplift pressure distribution along the base can be drawn and is summed up to get the pressure below the dams.
- **Checking the possibility of piping beneath dams:** At foot or toe of the dam, when the upward exit hydraulic gradient approaches unity, boiling condition may occur leading to erosion in soil and consequent piping. Which may lead to corrosion of pipe and many dams on soil foundations have collapsed because of a sudden formation of a piped shaped discharge channel. And when the stored water rushes out, the channel widens and leads to the formation of catastrophic failure results. This is termed as piping failure.

8. CONCLUSIONS

The seepage forces are an important factor while studying erosion of soil, failure of dams, also while studying retaining of wall failure, as some times the forces are strong enough to reduce the total effective stresses of soil and lead to several disaster. Seepage is responsible for liquefaction of soil, as it disturbs the soil. Engineers have learned a great deal about the internal erosion and the effects of the seepage at the dam's sites.

We do the analysis for the seepage in order to prevent it from getting more dangerous to the ground water and the soil, preventing more loss in failures of structures.

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