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EXPERIMENTAL STUDY ON FLOW NET THROUGH MULTILAYERED SOIL BY USING HYDRAULIC MODEL

PRAVEENKUMAR G[1], JAMEER KHAN S[2], MOHAN RAJ P[3], PREM R[4], THARINI K[5]

[1,2,3,4] –Students, Department of Civil Engineering, SRM Valliammai Engg College, Chengalpattu, Tamilnadu.
[5]–Assistant Professor, Department of Civil Engineering, SRM Valliammai Engg College, Chengalpattu, Tamilnadu.

Abstract - *In this experimental study hydraulic modelling used to determine the flow net in order to analyse seepage flow through multilayered soil foundation underneath hydraulic structure and also to study the consequence of the cut-off inclination angle on exit gradient, uplift pressure and quantity of seepage by using seepage tank with inclined cut-off. The physical model (seepage tank) was designed with three cut-off angles which are 90˚, 45˚, 120˚, at both upstream and downstream. After study state flow line is constructed by dye injection in the soil from equipotential lines can be constructed by piezometer fixed to measure the total head. From the flow net we can able to identify the best place and cut-off inclination angle to reduce the seepage effect.*

Key Words: Flow net, Multi-layered soil foundation, Inclined cut-off wall, Exit gradient, Uplift pressure, Seepage quantity.

1-INTRODUCTION

Dams, weirs, sheet pile wall etc., are some of the engineering structures designed and constructed in such a way in order to operate them to control natural water or save industrial sources to guarantee optimum use of water. These structures are frequently built on soil material therefore analysis and design of foundation, as compared with other part of structure, should be given greater importance because failure in foundation would destroy the whole structure.

The differential head in water levels between the upstream and downstream acts on the foundation and causes seepage flow. The effect of seepage under the structure will generate uplift pressure on over laying hydraulic structure. When this uplift pressure greater than the overburden load acting downward will lift the structure from the surrounding strata which leads to catastrophic failure.

The quantity of seepage flow of water should be well under minimum for optimum use of stored water resource. The exit gradient of seepage flow should not be greater than the critical hydraulic gradient to prevent quick sand condition. To analyze seepage flow through the soil foundation flow net is constructed by using hydraulic model.

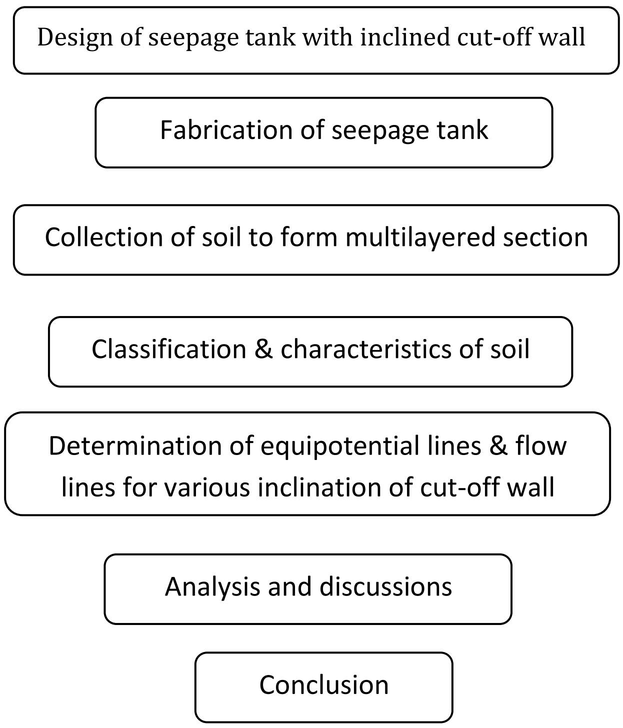
2-NEED FOR THE STUDY

In the construction of hydraulic structure such as dams, barrages etc., extensive study on seepage is conducted to control water loss through seepage and also to protect structures from failure due to the effect of seepage pressure in the foundation soil.

3-OBJECTIVE OF THE STUDY

1. To locate equipotential lines and flow lines by conducting experiments in seepage tank containing multi-layered soil sample.
2. To study the effect of different cut-offs inclinations on exit gradient, uplift pressure underneath the hydraulic structure, quality of seepage and to determine the optimum inclination angle of cut-off for upstream and downstream side of hydraulic structure

4-METHODOLOGY



5-DESIGN AND FABRICATION OF SEEPAGE TANK

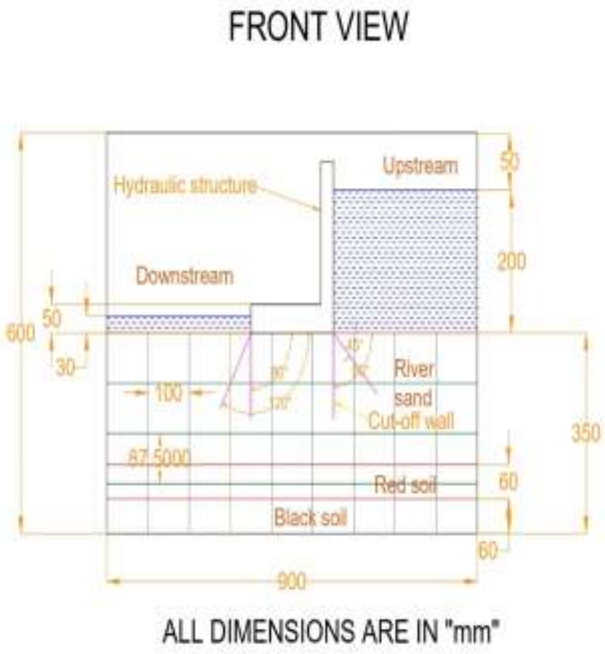


Fig -5.1: Front view of seepage tank

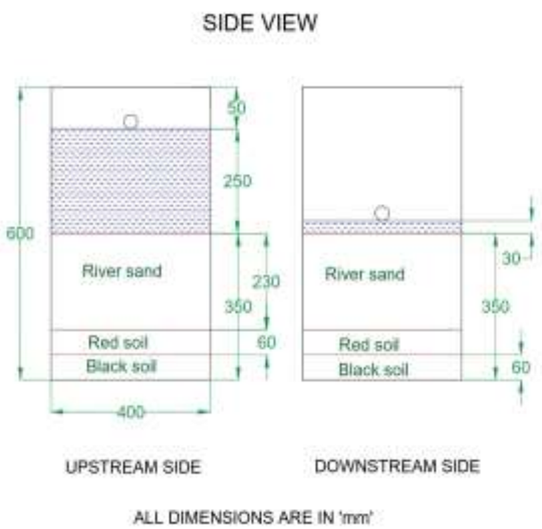


Fig-5.2: Side view of seepage tank

Hydraulic model was designed and fabricated in glass for a dimension of 900×600×400 mm. Hydraulic structure representing dam was modelled with 3 layer of soil below. Model was setup, with an inlet and outlet to maintain a constant head of 170 mm between the upstream and downstream levels. Cut-offs provided for a depth of 120 mm.

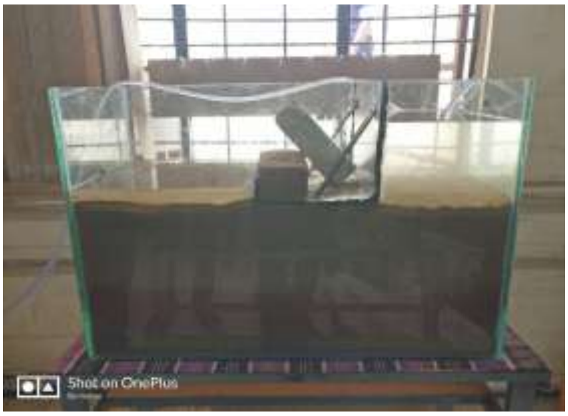


Fig-5.3: Front view of setup (hydraulic model)

Fig-5.4: Piezometric setup at the back side of the seepage tank

Tubes of diameter 6 mm were fixed at grids point with an interval of 100 mm. These tubes acted as the piezometers to determine the total head at grids to sketch the equipotential lines.

6-COLLECTION OF SOIL SAMPLE

In order to form multilayered soil strata for flow net study soil were collected from 3 different region. Soil samples obtained are shown in figure 6.1, 6.2 and 6.3

Fig-6.1: Sample-A (River sand)

Fig-6.2: Sample-B (Red soil)

Fig-6.3: Sample-C (Black soil)

- Sample – A (River sand) is collected from Chengalpattu.
- Sample – A (Red soil) is collected from Kattankulathur.
- Sample – A (Black soil) is collected from Chengalpattu

7-CLASSIFICATION AND CHARACTERISTICS OF SOIL

1. Grain size distribution of soil sample.
2. Hydraulic conductivity (permeability of soil)

7.1-Grain size distribution

Since >50% of the soil retained on 75 micron sieve, the soil is classified based on its grain size. The engineering behavior of the small particles would differ from relatively large particles that forms the basis of using size of the particle as a criterion for classifying soil. So in order to classify the soil size of the soil particles should be known for that purpose sieve analysis is used to determine the size of the particles. In India Bureau of Indian standards has adopted the soil classification system called IS classification system of soil. So we are going to classify the soil based on IS classification system by conducting sieve analysis test on soil samples.

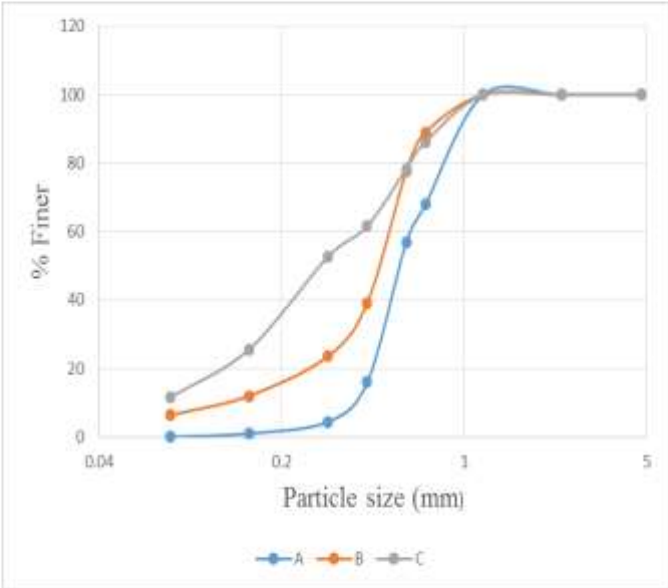


Fig-7.1: Particle size distribution curve

7.2-Hydraulic conductivity

The ease with the water can flow through the soil is called permeability of soil its unit is m/sec. For determining the permeability of the soil sample falling head permeameter is used.

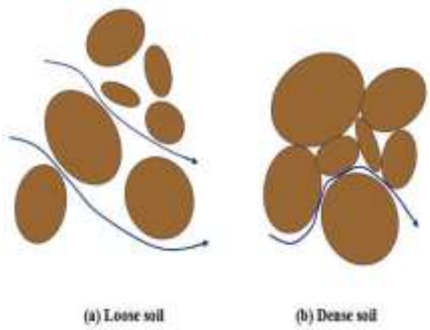


Table7.1: Classification & Characteristics of soil

Soil sample	Soil classification	Permeability (m/s)
A	SP	6×10^{-4}
B	SW	2.07×10^{-5}
C	SW - SM	9.75×10^{-6}

8-DETERMINATION OF EQUIPOTENTIAL LINES AND FLOW LINES

8.1-Procedure

1. Taking the datum to be at the bottom of the tank, install the soil in the form of three layer.
2. Feed the water to the seepage tank through the inlet hose until the water level in the upstream region reached the overflow hose level.
3. After reaching steady-state flow dye is injected using syringe at the specific points, after a period of time flow lines were drawn, which represents how the flow of water within the soil particles.
4. After drawing flow lines, the vertical piezometers were installed at the transparent glass vertically into the soil to measure the total head in the points to drawn the equipotential line.
5. Measure the discharge of drained water collected from the downstream using the volumetric method by using jar.
6. Record the reading of the piezometeric head of all installed piezometers.
7. Put the cut-off at upstream side with the angle of inclination for upstream (θ=45˚, θ=120˚, θ=90˚) and repeat the step to find the best angles gave less value of uplift pressure, exit gradient and quantity of seepage.
8. Put the cut-off at downstream side with the angle of inclination (θ=90˚, θ=120˚, θ=45˚) and repeat the step to find the best angles gave less value of uplift pressure, exit gradient and quantity of seepage.

8.2-Flow net for different cut-off inclination

Fig 8.1: Without cut-off wall (θ = 0˚)

Fig 8.2: Cut-off at upstream side θ = 45˚

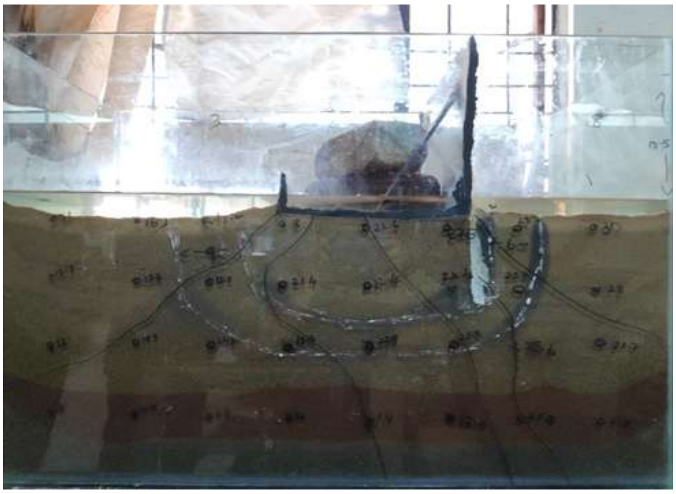


Fig 8.3 Cut-off at upstream side θ = 90˚

Fig 8.4: Cut-off at downstream side θ = 90˚

Fig 8.5: Cut-off at downstream side θ = 120˚

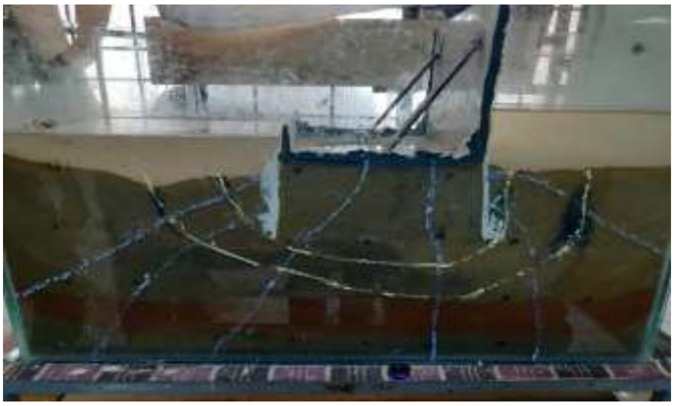


Fig 8.6: Cut-off at both U/S and D/S θ = 90˚

9- ANALYSIS AND DISCUSSIONS

9.1 Effect of inclined cut-off and its position on the uplift pressure

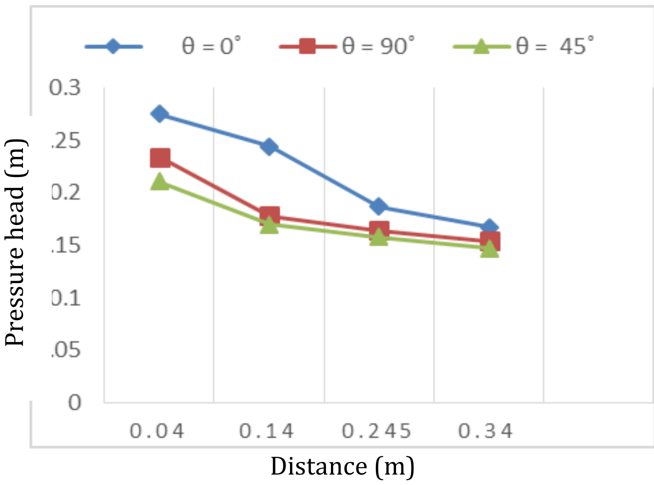


Fig 9.1: Uplift head for different values of (θ) for cut-off in U/S

As shown in figure (9.1) when cut-off in upstream side of hydraulic structure was inclined with different angles, it is noticed that the uplift pressure underneath the hydraulic structure decreases as θ decrease toward U/S. For (θ = 90˚, 45˚) where maximum reduction in uplift pressure according to the general case θ = 0˚ was 28%, 30.3%, respectively, so that the best angle is 45˚.

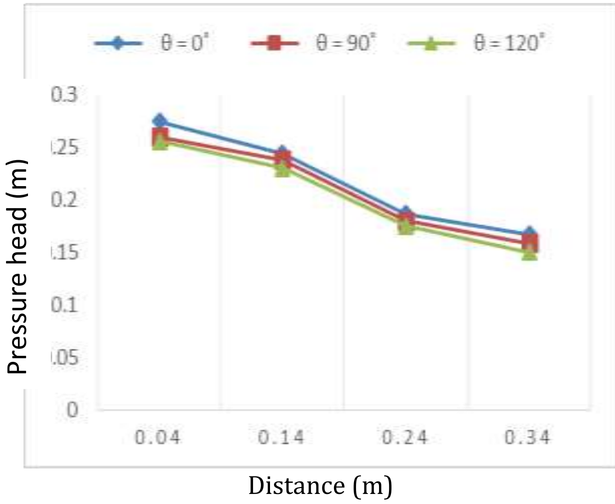


Fig 9.2: Uplift head for different values of (θ) for cut- Off in D/S

From figure 9.2, when the cut-off in downstream side of hydraulic structure is used, the uplift pressure obtained decreases as θ decreases towards U/S side for θ = 120˚, 90˚. For (θ = 120˚, 90˚) where maximum reduction in uplift pressure according to the general case θ = 0˚was 6.9%, 5.4%. It is clear that reduction in uplift pressure is minimum. So, it is not recommended to use cut-off wall under any angle of inclination at downstream.

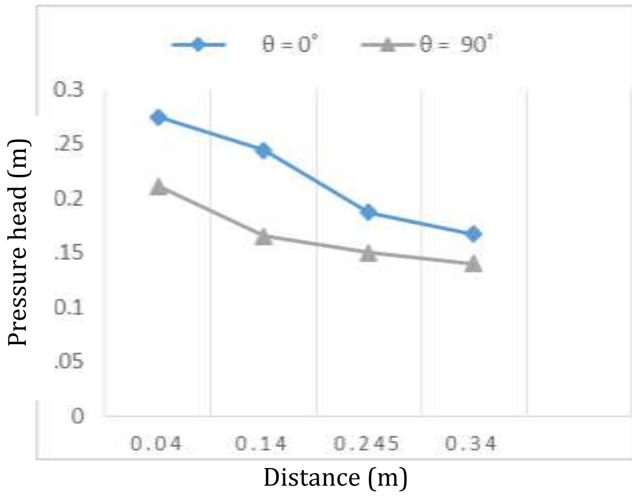


Fig 9.3 Uplift head for different values of (θ) for cut-off in U/S and D/S

As cut-off wall positioned in U/S and D/S part of hydraulic structure as shown in figure 9.3, the uplift reduced strongly with maximum difference of uplift pressure was 32.3%.

9.2- Effect of inclined cut-off and its position on Exit Gradient

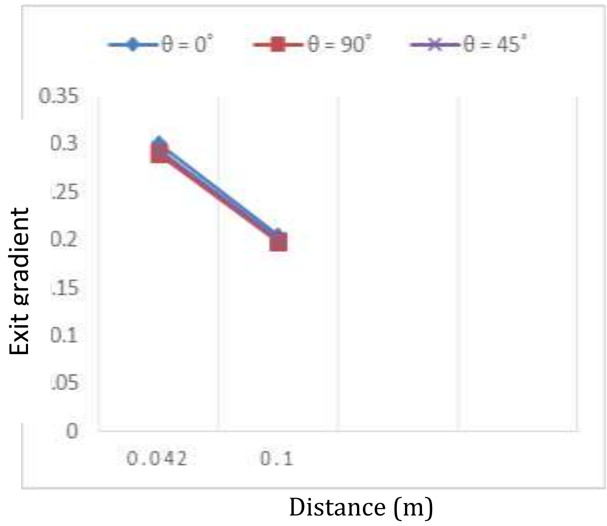


Fig 9.4 Exit gradient values for different θ values for Cut-off in U/S

From figure 9.4, when the cut-off put in upstream side of hydraulic structure it is found that the reduction in values of exit gradient were so small and as follows for θ = 45˚, 90̊, where the maximum reduction in exit gradient when compared to the θ =0̊ is 2%, 3.3%.

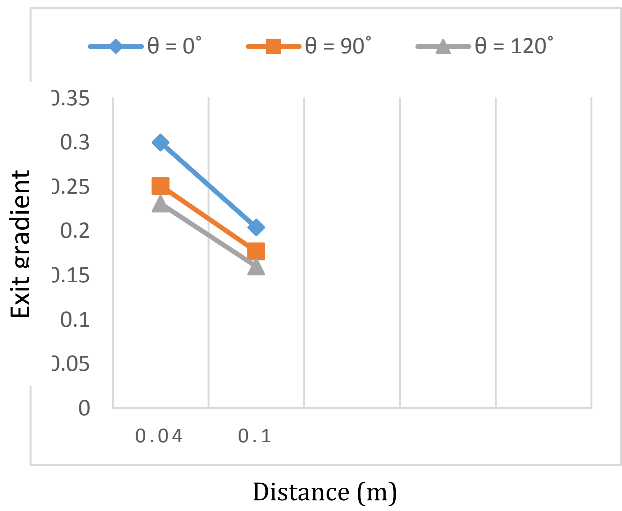


Fig 9.5: Exit gradient values for different θ values for Cut-off in D/S

From figure 9.5, when the cut-off put in upstream side of hydraulic structure the exit gradient decreases as θ increases toward the D/S for θ = 90˚, 120̊ the maximum reduction in exit gradient according to the general case θ = 0˚ are 16.3%, 23% respectively. These results shows that using cut-off in D/S with inclination angle of θ = 120̊ increase the safety against the sand boiling.

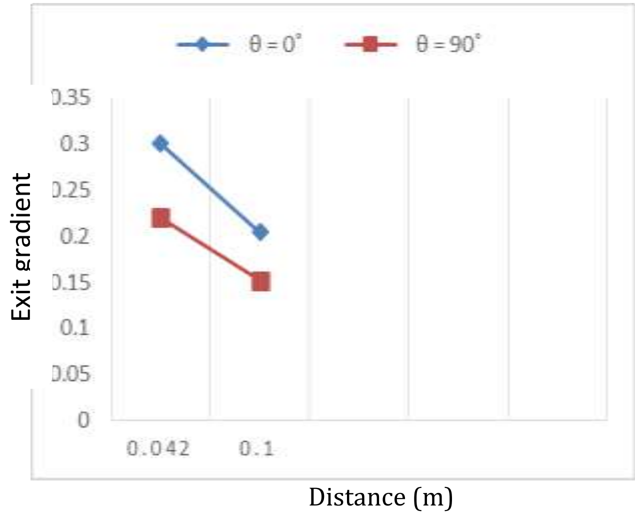


Fig 9.6: Exit gradient values for different θ values For cut-off in U/S and D/S

As cut-off wall positioned in U/S and D/S part of hydraulic structure as shown in figure 9.6, the exit gradient reduced with maximum difference of uplift pressure was 26.6 %.

9.3 Effect of inclined cut-off and its position on the Seepage quantity

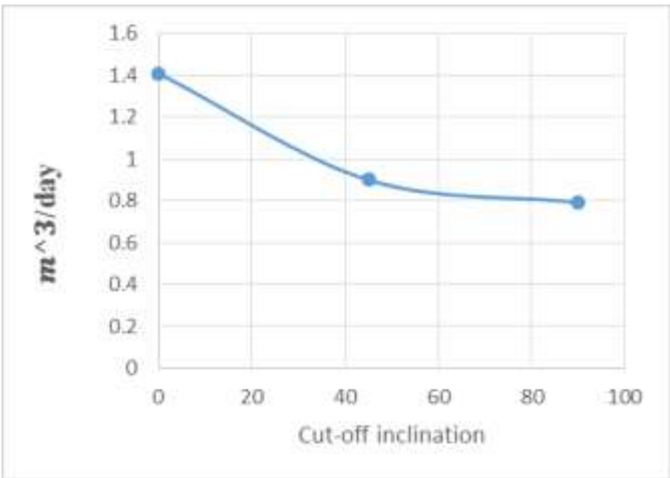


Fig 9.7: Seepage quantity range of different values of θ for Cut-off in U/S

When the cut-off is in U/S side, it is found that least quantity of seepage occurred when θ =90˚.

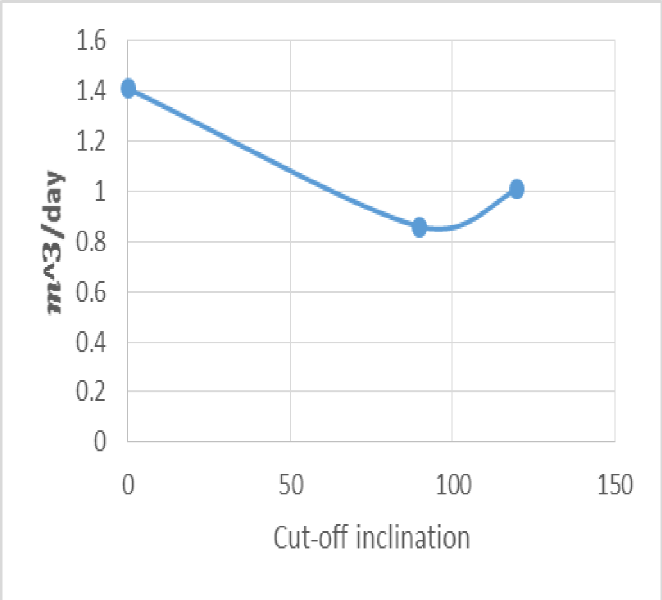


Fig 9.8: Seepage quantity range of different values Of θ for cut-off in D/S

When the cut-off is in D/S side, it is found that least quantity of seepage occurred when θ = 90˚. But the quantity is still more when compared to U/S.

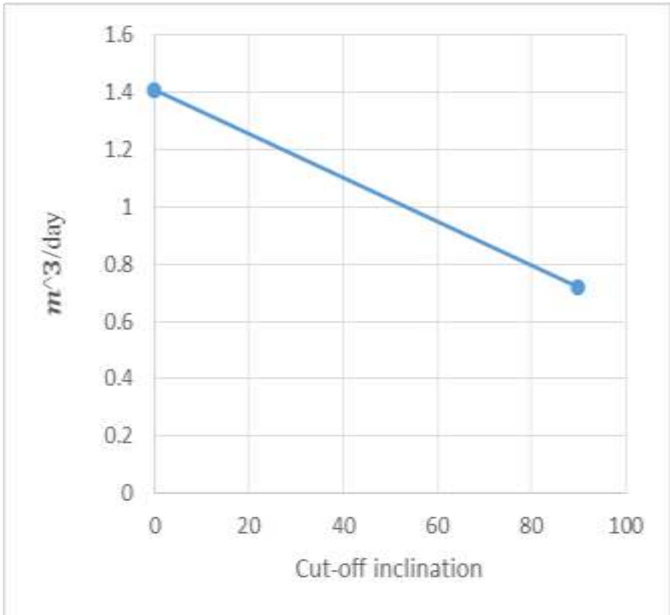


Fig 9.9 Seepage quantity range of different values of θ for cut-off both U/S and D/S

When the cut-off in both U/S and D/S part the seepage quantity decreases when compared with general case as shown in fig 9.9

10-CONCLUSIONS

1. The minimum value of uplift pressure (30.3% reduction in uplift pressure when compared to without cut-off wall case) was obtained when the cut-off used in upstream part of hydraulic structure is at the right angle of inclination (θ=45˚).
2. The minimum value of the exit gradient (23% reduction in exit gradient when compared to without cut-off wall case) in downstream side was obtained when cut-off used in downstream part of hydraulic structure is at angle (θ=120˚).
3. The minimum value of seepage quantity (42.85% reduction in seepage quantity when compared to without cut-off wall case) was obtained when the cut-off used in upstream part of hydraulic structure was at angle (θ=90˚).
4. Using double cut-off at the upstream and downstream side of dam at right angle reduced the uplift pressure, exit gradient and quality of seepage at the same time.

REFERENCES

[1] Aburohim, M. A., (1992) "Experimental study for the effect of seepage past hydraulic structures on the uplift pressure along the flow", Alexandria Engineering Journal, Volume 31, Issue 1.

[2] Arslan, C.A. and Mohammad, S.A. (2011). "Experimental and Theoretical Study for Piezometric Head Distribution under Hydraulic Structures". Department of Civil Engineering; College of Engineering, University of Kirkuk Volume 6, No.

[3] Desai S.C. and Christian T.J. (1977). "Numerical Methods in geotechnical engineering. "McGraw-Hill Book Company, New York.

[4] Najm, O. S. A. and Hala, K. T. A., (2015) "Experimental Study for Piezometeric Head Distribution Under Hydraulic Structures" International Journal of Scientific and Technology Research Volume 4, Issue 04.

[5] Shashi, K. G. and Manoj, D., "Geotechnical Engineering", Tata McGrew-Hill publishing Company Limited, New Delhi, 1985.

[6] Zheng-yi F. and Jonathan T.H. (2006). "The epsilon method: Analysis of seepage beneath an impervious dam with sheet pile on a layered soil. "NRC Research Press, Canada Geotechnical Journal Volume 43, P59-69.