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CALCULATION OF THE INFILTRATION CURVE THROUGH AN EARTH DAM

BY

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Abstract. Determining the level of infiltration through the body of an earth dam is a problem that affects both design and exploitation. Of great importance, in this respect, is the establishment of the outflow point on the downstream slope.

In the literature, there are numerous methods of drawing the infiltration curve and setting the point of outflow, and depending on the author, they are based on some simplifying assumptions. For this reason, the results obtained by two methods may be different.

Currently, these calculations are made more and more with specialized software. Infiltration calculation programs are based on methods developed by various authors, but they have the advantage of combining them with other complementary methods (*e.g.* the finite element method). For this reason, the results obtained may be closer to what is actually happening

In this paper, is made a comparison of the results obtained with two analytical methods and the GeoStudio Seep/W program**.**

Keywords: dam; infiltration ; Dupuit ; Casagrande ; Geoslope.

1. Introduction

The program developed by Geoslope International Calgary Alberta, Canada, is comprised of a package of modules that can calculate different

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demands for certain dams and massive earth. Beginning with the calculus of infiltrations, the stability of the slopes, to seismic simulations.

The Seep/W module is the component part of this that can be used to analyze infiltrations through an earth dam. The main advantage for students is that for relatively simple calculation schemes, it can be used in the Student variant. The calculations have the same accuracy, but the number of elements and features that can be entered into the program is limited.

2. Content

It is considered a dam made of homogeneous cohesive soil, which has a height H = 5 m, the width of the crown l = 3 m, and the inclination of slopes of 1:2. The upstream water level is h = 4 m. (Fig. 1)

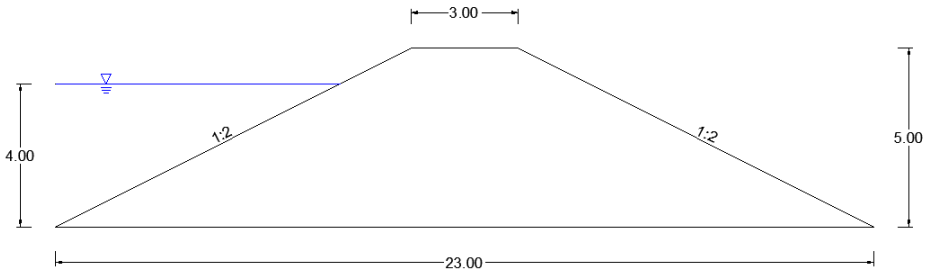

Fig. 1 – Cross section through the dam.

a. Dupuit method

Calculation scheme for the infiltration curve for Dupuit method is drawn in Fig 2.

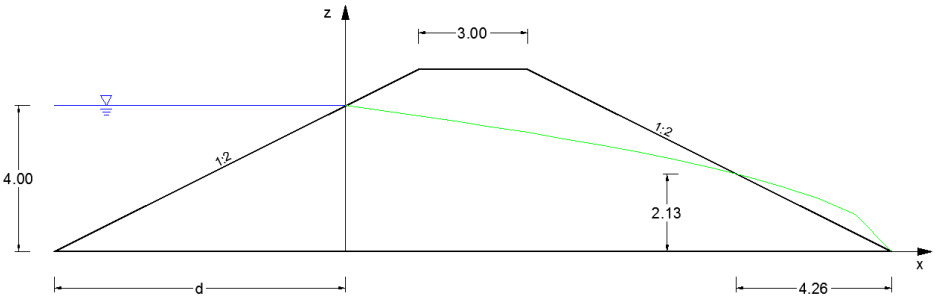

Fig. 2 – The infiltration curve for Dupuit method.

The equation for drawing the infiltration curve has the following form:

$$z^2 = H^2 - \frac{x}{d}\left(H^2 - H_1^2\right), \tag{1}$$

when: H is upstream water level, [m]; H_1 – downstream water level, [m]; z, x – the coordinates of the parabola, [m]; d – the distance between the upstream leg and the point of intersection of the water level with the slope, [m];

$$d = mH. \tag{2}$$

In this case, in the downstream there is no water, the equation becomes:

$$z = H\sqrt{1 - \frac{x}{mH}}. \tag{3}$$

For drawing the parabola, values will be given to x (Table 1) and thus will be obtained pairs of values (x, z), and by a graphical representation of these points, will be obtained the shape of the infiltration curve (Fig.1).

Table 1

Coordinates to Draw the Infiltration Curve with the Dupuit Method

x	z	x	z
0	4.000	8	2.733
1	3.864	9	2.530
2	3.724	10	2.309
3	3.578	11	2.066
4	3.425	12	1.789
5	3.266	13	1.461
6	3.098	14	1.033
7	2.921	15	0.000

b. Casagrande method

In the method formulated by Casagrande, he hypothesizes that the parabola intersects the water level at a distance of 0.7d from the upstream foot of the dam (Fig. 3)

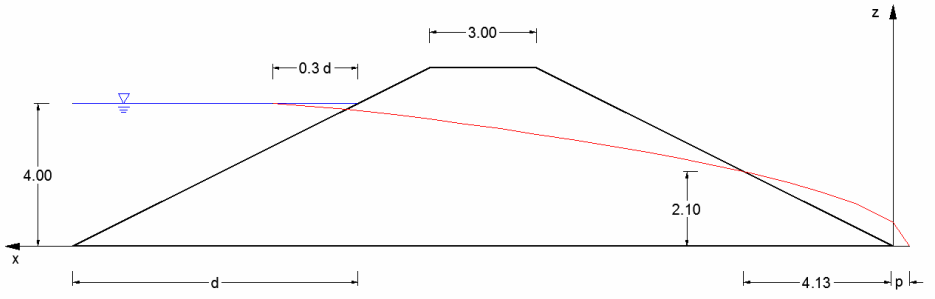

Fig. 3 – The infiltration curve for Casagrande method.

The equation of infiltration parabola has the following form:

$$z^2 = 4p(x + p), \tag{4}$$

when: p is the distance from the downstream foot and the point of intersection of the parabola with the abscissa, [m];

$$p = \frac{\sqrt{d^2 + H^2} - d}{2}. \tag{5}$$

As with the Dupuit method, values will be given to x (Table 2), obtaining pairs of form (x, z). Graphic representation is shown in Fig. 3.

Table 2

Coordinates to Draw the Infiltration Curve with the Casagrande Method

x	z	x	z
$-p$	0.000	8	2.828
0	0.944	9	2.991
1	1.667	10	3.145
2	2.161	11	3.291
3	2.561	12	3.432
4	2.906	13	3.567
5	3.215	14	3.697
6	3.496	15	3.822
7	3.757	15+0.3d	4.000

c. GeoStudio SEEP/W

As we have seen in the previous methods, the drawing equations of the infiltration curve do not take into account the permeability coefficient of the earth or other parameters, but only if the soil is cohesive or non-cohesive.

In order to draw the infiltration curve with the Seep/W module, it's necessary to select a type of cohesive soil (clay, dust, sandy clay etc.) for soil characteristics.

After that, the constraints are as follows:

– Upstream: water level is H = 4 m (Fig. 4).

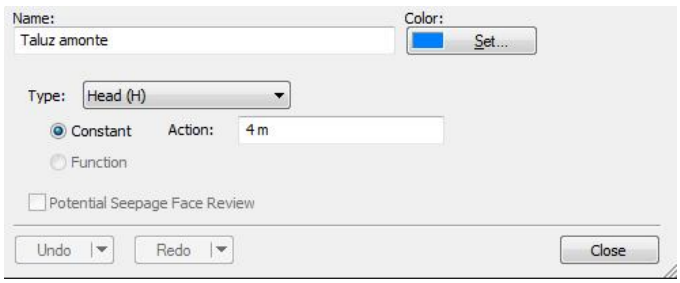

Fig. 4 – Upstream constraint.

– Downstream: The condition that there may be potential seepage face review (Fig. 5).

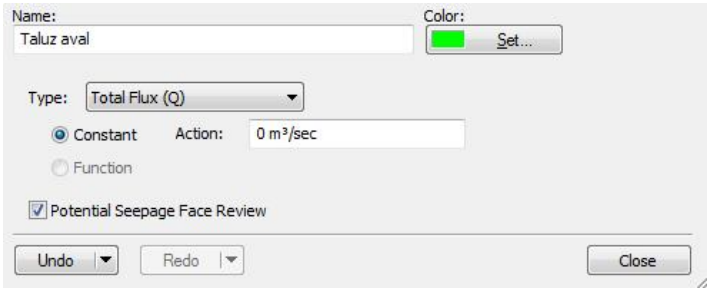

Fig. 5 – Downstream constraint.

After running the program, results the following infiltration curve (Fig. 6)

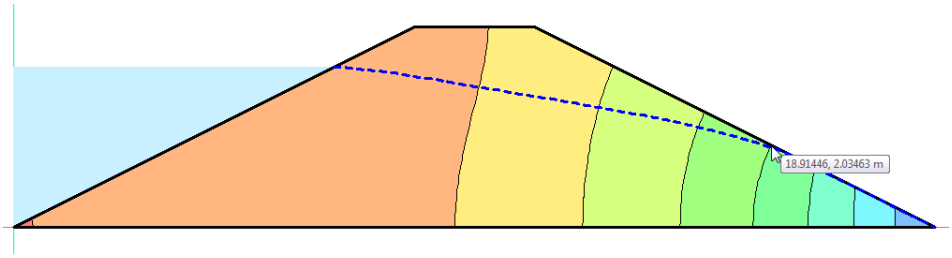

Fig. 6 – The infiltration curve for GeoStudio SEEP/W.

3. Conclusions

The calculations were made for the same dam by two analytical methods and with the help of a GeoStudio Seep/W program.

If we overlap the three obtained cubes, we notice that the differences are relatively small. The Dupuit curve almost overlaps with that obtained through the computerized program (Fig. 7). Towards of the outflow point, the 3 curves converge almost to the same point, providing close results (Table 3).

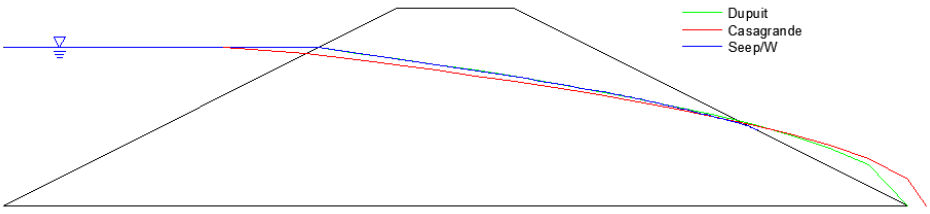

Fig. 7 – Overlapping of the 3 curves.

Table 3
The Height of the Outflow for the Three Methods Used

Method	Dupuit	Casagrande	Seep/W
h_i	2.13	2.10	2.03

In conclusion, the three presented methods can be used in the calculation of the infiltration curve, giving similar results for the position of the outflow point on the downstream slope. The Computerized Computing Program can be used by students as a method of verifying calculations performed analytically.

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CALCULUL CURBEI INFILTRAŢIILOR PRINTR-UN BARAJ DE PĂMÂNT

(Rezumat)

Stabilirea nivelului infiltraţiilor prin corpul unui baraj de pământ reprezintă o problemă ce influenţează atât proiectarea cât şi exploatarea acestuia. De mare însemnătate, cu privire la acest aspect, este stabilirea punctului de izvorâre de pe taluzul aval.

În literatura de specialitate există numeroase metode de trasare a curbei de infiltraţii şi de stabilire a punctului de izvorâre, iar în funcţie de autor, acestea se bazează pe anumite ipoteze simplificatoare. Din acest motiv, rezultatele obţinute prin două metode pot fi diferite.

În prezent, aceste calcule sunt realizate din ce în ce mai mult cu ajutorul softurilor specializate. Programele pentru calculul infiltraţiilor sunt bazate pe metodele dezvoltate de diverşi autori, dar ele prezintă avantajul îmbinării acestora cu alte metode complementare (ex. metoda elementului finit). Din acest motiv, rezultatele obţinute pot fi mai apropiate de ceea ce se întâmplă în realitate.

În lucrarea de faţă este realizată o comparaţie a rezultatelor obţinute cu ajutorul a două metode analitice şi cu programul GeoStudio Seep/W.