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CONSIDERATIONS REGARDING INFILTRATIONS COMPUTATION FOR AN EARTH DAM WITH A DRAINAGE PRISM. CASE STUDY: MÂNJEȘTI DAM

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Abstract: *Lately, for dams of high and medium importance in Romania, made of local materials, it was introduced new measuring and control equipment which, in its great majority, achieves automatic data readings and interpretations. One such example is the automatic reading devices of the water level in the dam piezometric wells. The main issue of interest is the calibration of the infiltration curve through a homogeneous earth dam resulted from automatic readings, with an infiltration curve resulted according to theoretical calculation. This paper presents such a computation for a homogeneous dam made of local materials, provided with a drainage prism at the downstream slope base.*

Key words: *infiltration curve, earth dam, drainage prism.*

1. Introduction

Mânjeşti dam is made of homogeneous earth filling and was brought into service in 1976. The dam is located on the Crasna River, upstream from its effusion in Bârlad River. The length of the barrier front is 815 m and the maximum height of the dam is 13.70 m. The height of the crest is positioned at 105.70 mdMN and the normal retention level in the barrier lake is situated at 100.00 mdMN.

The depression curve in the dam body is monitored with 6 piezometric wells, positioned in two sections as follows:

- In the control section S1, located 156 m from the right side, are positioned P1, P2 and P3 piezometric wells;
- In the control section S2, located 68 m from the left bottom discharge and 250 m from the left side, are positioned P4, P5 and P6 piezometric wells.

2. Theoretical Problem

For the case in which the homogeneous earth dam is provided with a drainage prism, the calculations can be performed using the modified "Numerov" formula.

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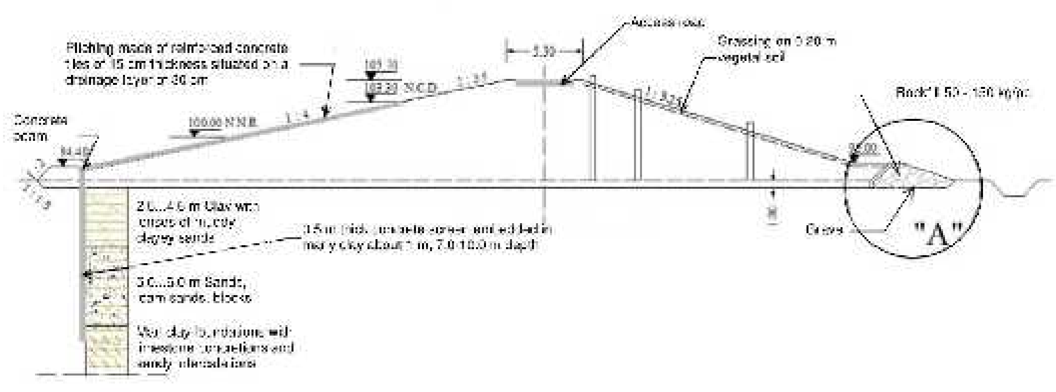

Fig. 1. *Characteristic cross section through Mânjești dam* [2]

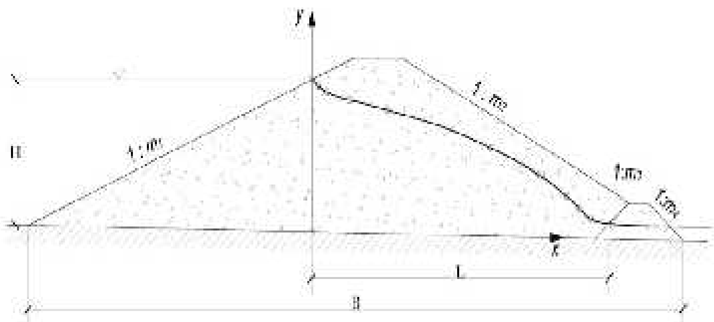

Fig. 2. *Calculation scheme of the infiltration curve through a homogenous earth dam with a drainage prism* [4]

$$x = \frac{H^2 - y^2}{2 \times \frac{q}{k}} - H \times F_1 + \frac{q}{k} \times F_2 \tag{1}$$

where:

$$\frac{q}{k} = \frac{H^2 - h^2}{L + H \times f_1 - h \times f_3 + \sqrt{(L + H \times f_1 - h \times f_3)^2 + (H^2 - h^2) \times (f_2 - f_4)}} \tag{2}$$

and

L – the length of the infiltration curve;

H – the water level in the lake;

h – the water level in the downstream race;

f_1 and f_2 are functions of m_1, shown in Table 1;

f_3 and f_4 are functions of m_3 and are shown in Table 2.

x and y are the coordinates of the free surface curve (y=0 ... H);

F1 and F2 are functions of two arguments : m_1 and

s=t ×h × (π × (H-y))/(2 × q/k)

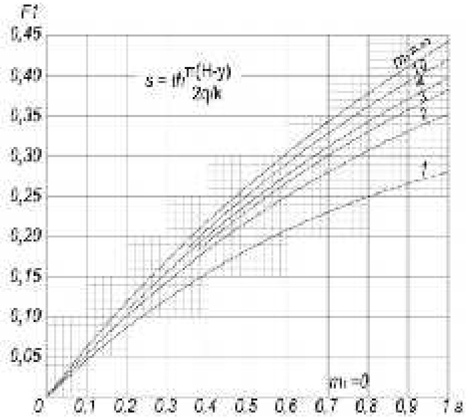

Fig. 3. *F1 calculation diagram using Numerov* [4]

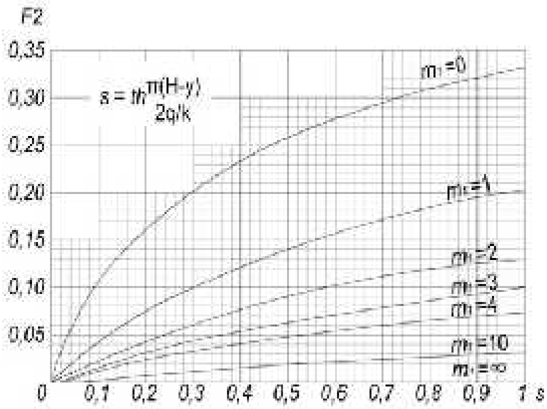

Fig. 4. *F2 calculation diagram using Numerov* [4]

f_1 and f_2 coefficients are based on the slope of the upstream bank m_1 and are chosen according to Table 1.

f_3 and f_4 coefficients are based on m_3 and are chosen according to Table 2.

Table 1

m_1	0	1	2	2.5	3	4	5	6	8	10
f1	0	0.28	0.35	0.37	0.38	0.40	0.41	0.41	0.42	0.42
f2	0.33	0.69	0.73	0.77	0.80	0.85	0.87	0.89	0.92	0.93

Table 2

m_3	0.75	1	1.25	1.50	1.75	2	2.5
f	1.02	0.725	0.550	0.439	0.370	0.312	0.240
f_3	0.51	0.72	0.94	1.17	1.41	1.65	-
f_4	0.17	0.15	0.13	0.11	0.10	0.08	-

3. Application of the theoretical problem in the case of Mânjești homogeneous earth dam with drainage prism

Regarding the data presented above, the calculation of the infiltration curve was performed in "theoretical" version using the "Numerov" method. Calculation results achieved in "Excel" are presented as spreadsheets and graphics below:3

The input data for the program and the obtained infiltration discharge Table 1

		q/k
H	8	0.478277
L	63.3	
f_1	0.39	
f_2	0.825	
h	1	
f_3	0.72	
f_4	0.15	

The coordinates x and y of the infiltration curve using Numerov method Table 2

y	**F_1**	**F_2**	**u**	**x (relative)**	**X (general)**
8	0	0	0	0	32
7.5	0.4	0.075	0.927765	4.902	36.902
7	0.4	0.075	0.997196	12.48129	44.48129
6.5	0.4	0.075	0.999895	19.53787	51.53787
6	0.4	0.075	0.999996	26.07174	58.07174
5.5	0.4	0.075	1	32.0829	64.0829
5	0.4	0.075	1	37.57135	69.57135
4.5	0.4	0.075	1	42.2548	74.2548
4	0.4	0.075	1	46.69783	78.69783
3.5	0.4	0.075	1	50.61816	82.61816
3	0.4	0.075	1	54.01577	86.01577
2.5	0.4	0.075	1	56.89067	88.89067
2	0.4	0.075	1	59.24287	91.24287
1.5	0.4	0.075	1	61.07235	93.07235
1.25	0.4	0.075	1	61.79108	93.79108
1	0.4	0.075	1	62.37912	94.37912
0.75	0.4	0.075	1	62.83649	94.83649
0.5	0.4	0.075	1	63.16319	95.16319
0.25	0.4	0.075	1	63.3592	95.3592
0	0.4	0.075	1	63.42454	95.42454

After the completion of the calculation done in Excel, it resulted a theoretical infiltration curve whose graphical representation is shown in Fig. 5:

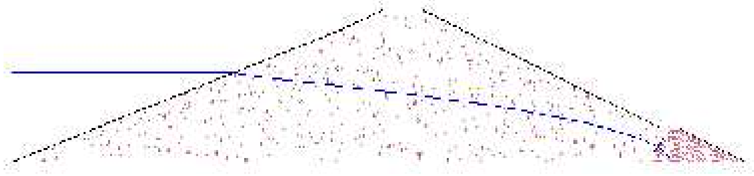

Fig. 5. *Theoretical infiltration curve in Mânjești dam*

4. Measured Data Regarding Infiltration Through Mânjești Dam

The evolution of the infiltration curve was observed in the period January 1997 - February 2015 by measuring hydrostatic levels in the 6 piezometric wells of the Mânjești dam. The graphs of the evolution of the water levels in the piezometric wells are listed below, together with a graph showing the variation of water level in Mânjești accumulation during the studied period.

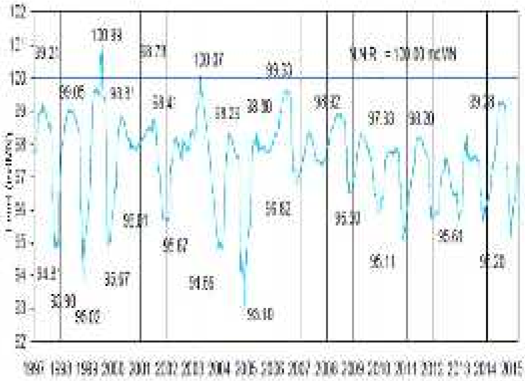

Fig. 6. *The level variation in Mânjești accumulation between January 1997 – February 2015* [1]

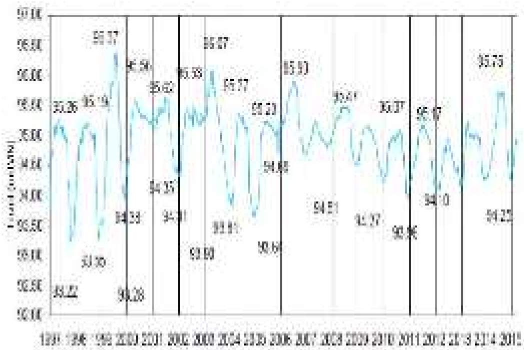

Fig. 7. *The water level variation in P1 piezometer of Mânjești dam during the study period* [1]

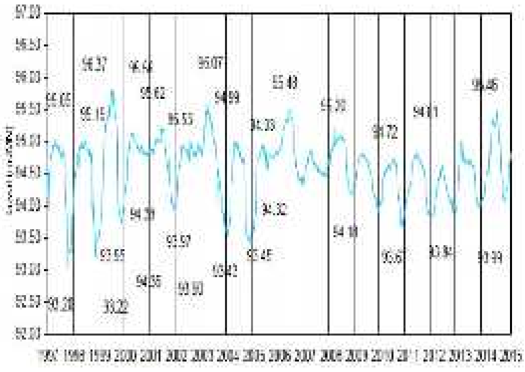

Fig. 8. *The water level variation in P2 piezometer of Mânjești dam during the study period* [1]

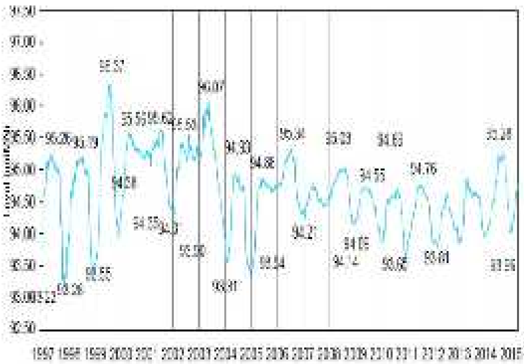

Fig. 9. *The water level variation in P3 piezometer of Mânjești dam during the study period* [1]

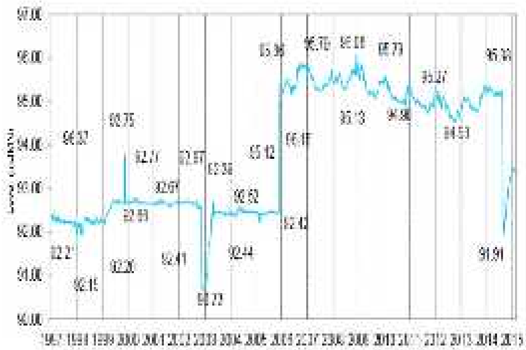

Fig. 10. *The water level variation in P4 piezometer of Mânjești dam during the study period* [1]

Fig. 11. *The water level variation in P5 piezometer of Mânjeşti dam during the study period* [1]

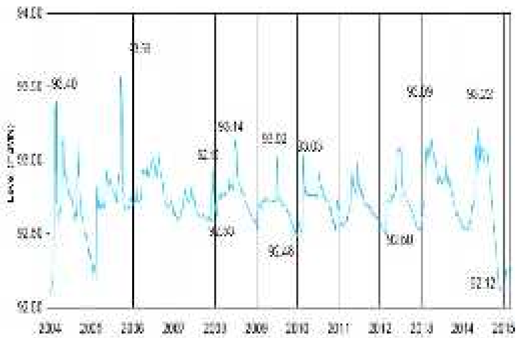

Fig. 12. *The water level variation in P6 piezometer of Mânjeşti dam during the study period* [1]

Comparing the variation in water level in the barrier lake with the variation in water level in the piezometric wells, it can be concluded:

- In the control section S1, piezometric wells P1, P2 and P3 show a good correlation between the level of infiltration and the changes in exterior applications throughout the year.

- In the control section S2, piezometric wells P4, P5 and P6 do not respond to the variation of external requests.

It can be observed that for the profile S1, the infiltration curve resulted from the calculation, made for two measured events (May 2002 and August 2009), corresponds to measurements made in the piezometric wells respectively.

5. Conclusions

In order to have reliable conclusions regarding the infiltration curve through an earth dam with homogeneous filling, disposed with a drainage prism, it is necessary to carry out readings of the water levels in the piezometers on a relatively large time period. It is also necessary to verify whether the readings variation corresponds for the piezometers located in a measurement profile. Once there is certainty on actual readings accuracy, resulting infiltration curve will have a similar behavior to that obtained theoretically.

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