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Research Article

ASSESSMENT OF THE TECHNICAL CONDITION OF OPERATED HYDROSYSTEMS OF CLASS IV

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ABSTRACT

The paper considers issues of assessing the level of safety of the technical condition of an operating hydrosystem of class IV. Using the measuring parameters of the hydrosystem, the positions of the depression curve and the specific flow rate in the body of the earthen dam are constructed. When performing numerical calculations of filtration, two calculation schemes were adopted, viz., a homogeneous ground dam without drainage and a dam on a permeable base with tubular drainage.

KEYWORDS

Hydrotechnical constructions, hydrosystem, technical condition, safety, filtration, depression curve, soil, water, dam.

INTRODUCTION

It is challenging to design of hydrotechnical constructions of class IV in the absence of regulatory and design documents. Existing requirements for ensuring the safety level of domestic hydrotechnical

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constructions of class IV do not fully satisfy and meet assessment requirements of technical conditions of hydrotechnical constructions [1-7]. Most class IV hydrotechnical constructions have been in operation for more than 60-70 years, which exhausted their technical condition. Therefore, the assessment of the technical condition of the operated class IV hydrotechnical constructions for ensuring the level of safety is very relevant. One of such facility is Novbakhor hydrosystem plant, which is located in the floodplain of the Zeravshan river 150-200 m below the discharge of Navoi Thermal Power Plant. The floodplain site at the location of the infrastructure has a flat surface with an absolute elevation of 325.5-326.5 m with a general slope to the west. In the north, the site is limited by the ledge of the first terrace up to 1.0 m height.

The geological structure of the site is monotonous and characterized by the development of gray fine earth from the surface of the sand. In the mechanical composition of sand, fragments with dimension from 0.5-0.1 mm> 50-60% prevail. Small pebbles, gravelly alluvial genesis, with a thickness of 2.5-4.0 m ubiquitously lie under the sands. Dimension of soil fragments is given in table 1.

Table 1

Dimension of soil fragments

80-40 mm	40-20 mm	20-10 mm	10-5 mm	5-2 mm	< 0.05 mm
8.15%	32.7%	27.2%	10.4%	2.3%	1.76%

The soil is characterized by the following indicators: the soil is not homogeneous> 100; the average particle size is 19.6 mm; homogeneity coefficient - 0.4; density of soil particles - 2.7 ton force per cubic meter; density of dry soil - 1.9-2.1 tf/m3; porosity - 26%; porosity coefficient - 0.350; the angle of repose is 40°. Under the pebbles, conglomerates lie everywhere, pebbled on calcareous cement. Exposed bed thickness is up to 15.0 m depth. Groundwater level at a depth of 1.0-2.0 m. Groundwater salinity 0.7-1.0 g/l. The climate of the region is characterized as an extreme continental. The seismicity of the area is 7 points. The hydraulic system is designed to provide water for irrigation of 24,000 ha in two right-bank canals: Kanimekh-1 (18 m3/s) and Naukar (8.1 m3/s).

The hydrosystem was commissioned in 2000. Since the initial commissioning of the hydrosystem, no field studies or visual examinations of the unit have been conducted. The hydrosystem includes a supply channel, a non overflow earthen dam, a shield dam, a Kanimekh-1 channel regulator, a Naukar channel regulator and a discharge channel (figure 1).

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Figure 1. General view of the earthen dam from the upstream side

It is known that when examining the technical condition of a hydrosystem, the filtration process or mode is considered as a particular practical interest. Since the adverse effects of filtration on the condition of the hydrosystem often cause the destruction of the construction or breaks down. During inspection of technical condition of the hydrosystem with specialists of the State Inspectorate "Gosvodkhoznadzor" of the Republic of Uzbekistan, we raised questions on assessing the level of safety of filtration processes in the body of an earthen dam.

METHODS

Calculations based and the position of the depression surface in earthen dams, along with other factors can ensure the stability of these units and define measures to reduce negative impact on stability. Data on filtration flow rate characterize the possible loss of water from the reservoir and necessary actions to perform certain measures to reduce negative affects. Information on the gradients and velocities of the filtration flow rate at the entrance point of the downstream is required to determine the filtration resistance of the soil to support and suffusion.

A non-overflow earthen dam is located on the left side of the shield dam and has a dimension of length of 250 m and a height of 5.1 m. The dam with 10.0 m width at the top is made of loam with enforcement of the upper slope with a dmid=25 cm torn stone. The total anchorage height is 7.6 m. In the lower part of the cladding, a tooth was arranged with a depth of 2.5 m of a trapezoidal shape, with the laying of slopes m=1.5 filled with torn stone. The downstream side of the mount does not have.

Experimental studies are carried out by measuring parameters for calculating the filtration processes in the body of the earthen dam of Novbakhor hydrosystem. No controlling and measuring instruments (i.e, piezometers) have been installed on site of the earthen dam for monitoring the position of the depressed surface of the dam.

In this study, the well-known hydraulic methods were used to calculate the amount of filtration in the body of the earthen dam of the Novbakhor hydrosystem. As a result of the calculation, the flow rate of water filtration in the body and base of the earthen dam, and the position of the depression curve are determined. In the beginning of the research, two design schemes

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were selected: a homogeneous earth dam without drainage and a dam on a permeable base with tubular drainage. It was found that the facility does not full the design documentation including operation manual of the facility.

1st design scheme. A homogeneous dam without drainage (figure 2). The vertical slope, according to the equivalent profile method, is located at a distance from the vertical passing through the point of intersection of the water level with the slope. According to the method of G.K. Mikhailov [8,9]

$$\frac{\Delta L}{H_1} = \frac{m_1}{(2m_1+1)},$$

where m_1 - coefficient of slope of the forebay;

H_1 - water depth in the forebay, m.

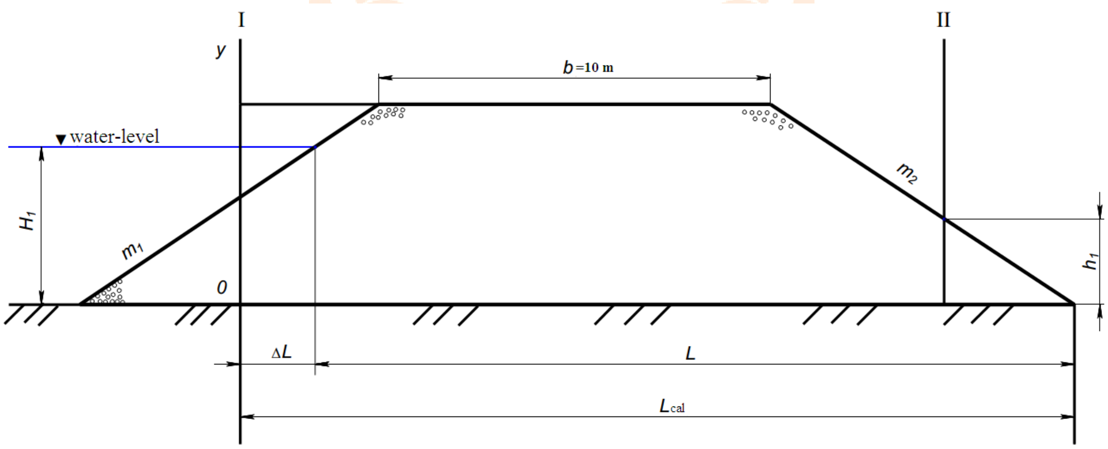

Figure 2. The design scheme of a homogeneous dam without drainage

By using the Dupuis equation for sections I-I and II-II, the specific filtration rate is determined by following formula

$$\frac{q}{K_f} = \frac{H_1^2 - h_1^2}{2(L_{cal} - h_1 m_2)},$$

where K_f - soil filtration coefficient of the dam body, m/day ($K_f = 0,1$);

$$L_{cal} = \Delta L + L,$$

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L - is the horizontal distance from the water edge in the forebay to the bottom of the lower slope, m;

m_2 - coefficient of slope of the afterbay.

The specific filtration rate is 0.04 m/day. Then using the equation of the lower wedge of N.N. Pavlovsky, we get fowling equation:

$$\frac{q}{K_f} = \frac{h_1}{m_2},$$

The joint solution of these equations gives the calculation formula:

$$h_1 = \frac{L_{cal}}{m_2} - \sqrt{\left(\frac{L_{cal}}{m_2}\right)^2 - H_1^2}.$$

The equation of the depression curve at the origin at point 0 according to the Dupuis formula has following form:

$$y^2 = \frac{H_1^2 - 2qx}{K_f}.$$

RESULTS. The calculation results of the position of the depression curve are summarized in table 2.

Table 2

Coordinates of the depression curve in a homogeneous earthen dam of Novbakhor hydrosystem

Water level, m	Distance												
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}
327,1	3,9	3,8	3,59	3,36	3,12	2,85	2,56	2,24	1,85	1,36	0,53	-	-
326,1	2,93	2,86	2,71	2,55	2,38	2,20	2,01	1,79	1,54	1,24	0,84	0,54	-
325,1	1,96	1,91	1,82	1,72	1,61	1,50	1,38	1,25	1,10	0,93	0,72	0,58	0,41
324,1	1,96	1,92	1,83	1,74	1,64	1,54	1,43	1,31	1,18	1,03	0,85	0,75	0,63

Based on data of the table, depression curve of the earthen dam is shown in figure 3.

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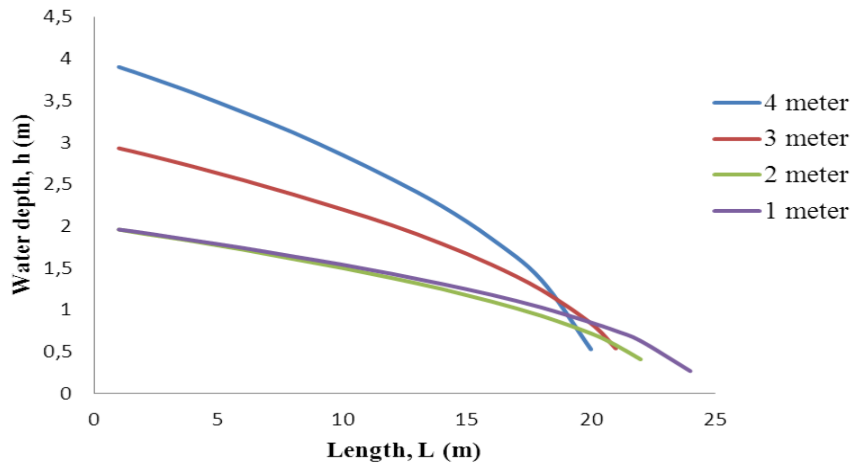

Figure 3. Graph of the depression curve of the earthen dam of Novbakhor hydrosystem

2nd ***design scheme. A dam on a water-permeable base with a tubular drainage of final capacity (*** $K_f < K_{base}$ ***) (figure 4).*** Specific filtration flow rate is determined by the following formula [10]

$$q = K_f \frac{H_1^2}{2L_{cal}} + K_{base} T \frac{H_1}{L_{cal} + 0{,}4T},$$

where $L_{cal} = \Delta L + L$; $\Delta L = \dfrac{\sigma\alpha_3 - \alpha_2\alpha_1}{\sigma + \alpha_1}$; $\sigma = \sqrt{\dfrac{K_{base}}{K_f}}$; $\alpha_1 = 2m_1 \dfrac{H_1}{T} + \dfrac{1{,}32}{m_1} - 1$;

$$\alpha_2 = \frac{m_1 H_1}{2m_1 + 1};\ \alpha_3 = m_1 H_1 + 0{,}4T,$$

T - thickness of the base layer, m;

K_{base} - soil filtration coefficient of the dam base, m/day ($K_{base} = 17$).

The specific filtration rate is 7.02 m/day.

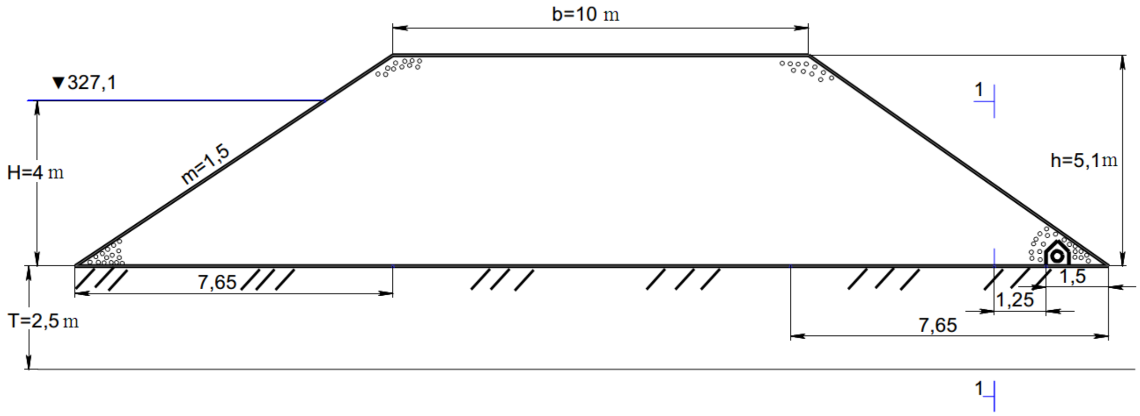

Figure 4. The design scheme of the dam on a permeable base with tubular drainage of finite thickness

The ordinates of the depression curve:

a) between section I-I and drainage

$$h_x = \frac{h_c^2}{T}\sqrt{\left[\left(\frac{T}{h_c}\right)^2 - 1\right]\left(1 + 2\frac{L-x}{T}\right) + 1},$$

b) between section I-I and the ordinate axis,

$$h_x = \sqrt{2\frac{q}{K_f}\left(L + \frac{T}{2} - x\right) + \left(h_c + \frac{K_{base}}{K_f}T\right)^2} - \frac{K_{base}}{K_f}T,$$

For the given scheme, h_c is calculated from following equation:

$$h_c = \sqrt{\left(H_1 + \frac{K_{base}}{K_f}T\right)^2 - 2\frac{q}{K_f}\left(L_{pac} - \frac{T}{2}\right)} - \frac{K_{base}}{K_f}T.$$

The depression curve is corrected visually in the zone

where $h_x = H_1 - \dfrac{q}{K_f}$.

RESULTS. The calculation results of the position of the depression curve are summarized in table 3.

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Table 3

Coordinates of the depression curve in the homogeneous earthen dam of the Novbakhor hydrosystem

Water level, m	Distance											
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327,1	3,17	2,85	2,52	2,19	1,86	1,53	1,20	0,87	0,54	0,21	-	-
326,1	2,51	2,27	2,03	1,79	1,55	1,31	1,07	0,83	0,58	0,34	0,1	-
325,1	1,76	1,61	1,45	1,29	1,13	0,98	0,82	0,66	0,50	0,35	0,19	-
324,1	0,93	0,85	0,78	0,70	0,63	0,55	0,47	0,40	0,32	0,24	0,17	0,09

Based on data of the table, depression curve of the earthen dam is shown in figure 5.

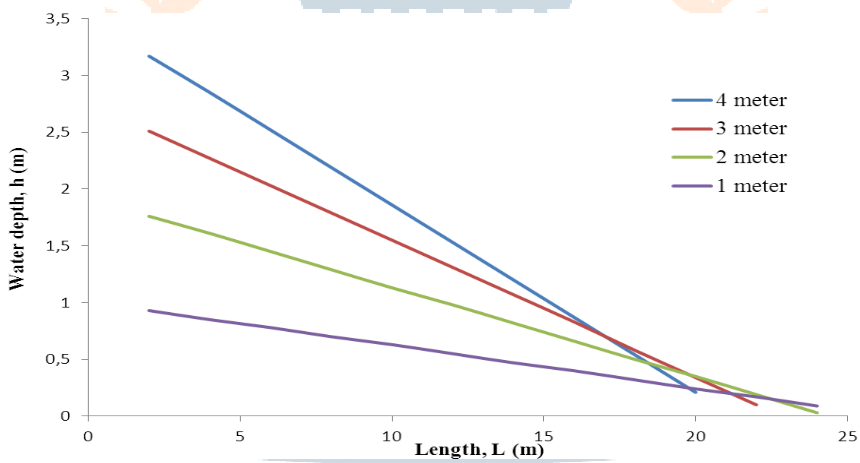

Figure 5. The graph of the depression curve of the earthen dam of Novbakhor hydrosystem

CONCLUSIONS

Experimental researches have been carried out and real data have been obtained for filtering water through an earthen dam in the example of the Novbakhor hydrosystem. In figure 3, a sharp decline at 4 meter in the position of the depression curve in the earthen dam was observed. In accordance with opinion of the authors, maintaining the water level of the forebay of the hydrosystem at the mentioned level might lead to an unfavorable circumstance of an earthen dam. Despite the above-mentioned outcomes, in general, the results of the researches maintain stability of filtration in the body of the earth dam.

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