Determination of Filtration Strength and Initial Filtration Gradient in Soil Constructions

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Abstract--- The “wall in the ground” method is effective when used in various engineering-geological and hydrogeological conditions and in many cases makes it possible to abandon the construction of sheet piling walls, various types of fastenings, dewatering and freezing. This method performs three main functions: the supporting elements of the base, retaining walls and impervious curtains. Bearing and retaining walls are usually reinforced, Anti-filtration structures are made without reinforcement.

Keywords--- Wall in the Ground, Permeability, Reservoirs, Bentonite, Filtration Coefficient, Pressure, Soil, Sand, Water.

I. Introduction

The method of “wall in the ground” will be used in devices of various kinds of underground structures, industrial, energy and civil buildings [1,3].

The basic principle of the construction of "walls in the ground" is the development of excavations in the soil, trenches or wells, which are subsequently filled with materials that provide low water resistance and durability of structures [2,4].

In hydro technical construction, most often “a wall in the ground” was used to create impervious elements at the base of dams in highly permeable alluvial soils, forming a much more reliable filtering barrier than the injection curtain [5,8,9]. In this case, the materials used are the most diverse and, in accordance with this, different methods of creation. Previously (at an early stage of use), the trench was passed “dragline” under the protection of a solution of bentonite clay, and then filled with a mixture of excavated highly permeable soil with clayey soil (the proportions of clay were determined by special studies).

II. Method and Materials

As is known, the filtration strength of the material of the curtain in accordance with KMK 2.02.02-98 n4. provided subject to the following condition:

$$J\,p \leq J_{dop}\ .; \qquad (1)$$

$$J\,p = \Delta h / t. \qquad (2)$$

Where J_p - the calculated value of the gradient of the current pressure of the filtration flow

J_{dop}- is the permissible gradient of the filtration flow;

Δh - level difference before and behind the curtain, m

t - Curtain thickness, m;

For the highest value of the dam height (23m), the approximate mark of NPS = 416 m and the average depth of the groundwater level = 393.0 m, Δh = 20m, the maximum value of the calculated pressure gradient is:

$$Jp = 20 / 0.6 = 33m$$

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According to our research (see below) in soils with a filtration coefficient of up to 200m / day (for lumpy clay of an approximate dam), the allowable pressure gradient Jdop = 40 should be accepted. Thus, the condition of the curtain's filtration strength at a curtain body thickness of 0.6m clay is performed along the entire route of the air curtain. For the conditions of maximum design head, that is, respectively, 33 <40 is fulfilled.

As is known, the initial filtration gradient in clays is manifested in the fact that the movement of water in them begins only after the pressure gradient exceeds a certain critical value. According to the experiments of V.M. Goldberg and N.P. Skvortsova, the initial gradient for clays varies from 10 to 100. For clays of the Logonsky deposit (which was used in the construction of the reservoir), the plasticity number is up to 27, the initial filtration gradient is from 40 to 70. For the conditions considered, the thickness is the curtain is 0.6m and the maximum level difference of 20m is the maximum possible pressure gradient of 33m (20/0.6), which is below the minimum value of the initial filtration gradient (33 <40).

III. Discussion

When the thickness of the impervious curtain is 0.6 m and filling it with lumpy clay, filtering through the body of the curtain is expected slightly.

This is also confirmed by the filtration calculations carried out below, which determined the position of the depression curve in the body of the dam.

Calculation of the filtration of an approximate dam without an impervious curtain. Initial data:

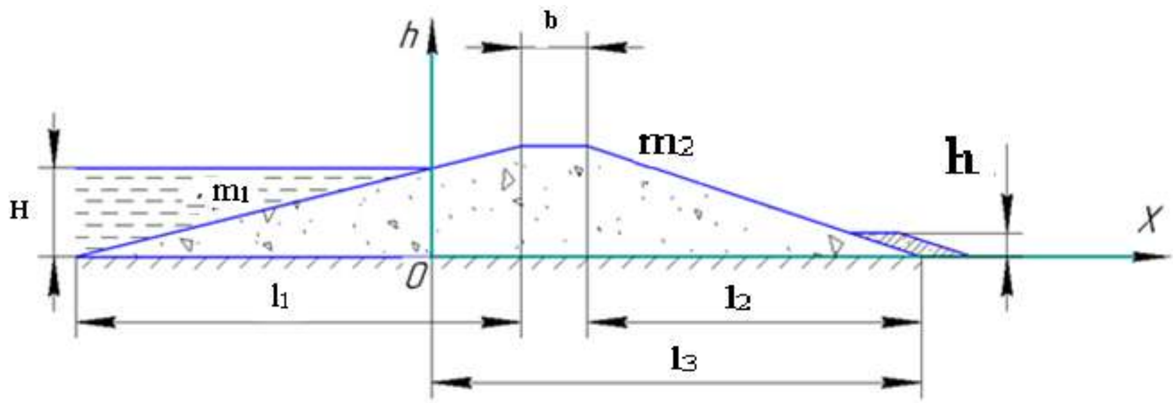

Figure 1

The calculation is made according to the method proposed by prof. Nedriga.VP. [6] p.124.

$$\begin{cases} \frac{q}{k_t} = \frac{H^2}{L + \sqrt{L^2 - m^2 * H^2}} \\ \frac{q}{k_t} = \frac{23^2}{130.2 + \sqrt{130.20^2 - 4.12^2 * 23^2}} = \frac{529}{219.489} = 2.41 \end{cases} \quad (3)$$

$$L_p = L + \Delta L_в \quad (4)$$

$L_p = 181 + 9.2 = 130.2м$

Since$m_1 \geq 2$, we take $\beta_B = 0{,}4$;

$$\Delta L_p = 0{,}4 * 23 = 9.2м$$

$$h_B = 4.62 * 2.41 = 11.13м$$

When m1 ≥ 1the value off$f(m_2) = 0.5 + m_2$(5),

$$f(m_2) = 0.5 + 4.12 = 4.62$$

According to the data obtained, we construct a depression curve:

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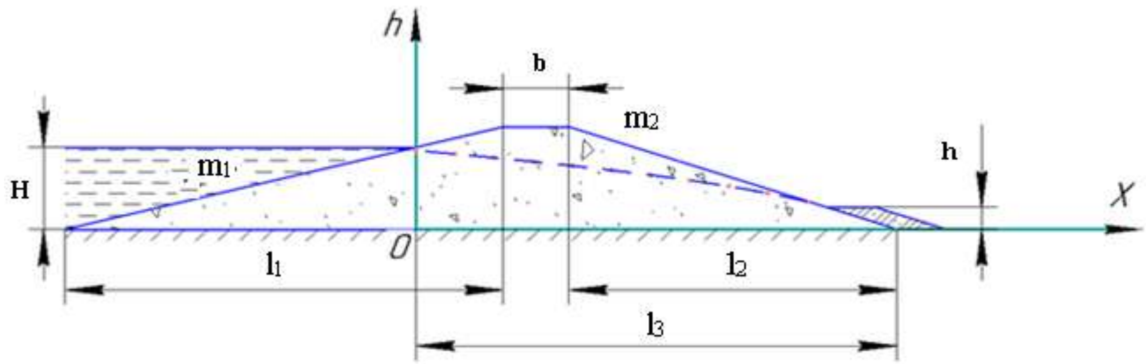

Figure 2

Calculation of the filtration of an approximate dam with an impervious screen.

Initial Data

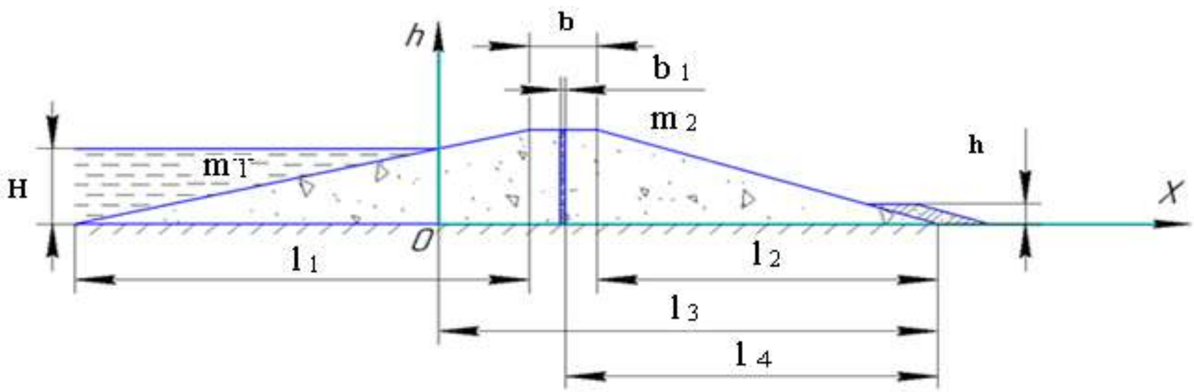

Figure 3

When filtering the calculation of such dams using the method of virtual lengths. For this, a nucleus with an average thickness δcp and with a filtration coefficient Kya leads to a prism with a filtration coefficient Кф. The virtual kernel length is determined by the dependencies:

$$\Delta L_{я} = \frac{К_{т}}{К'_{я}} * \delta_{ср.я}' \qquad (6)$$

$$\text{где: } k'_{я} = k_{я} + \frac{2k_{ос}+\delta_{ср.я}}{\pi(Н_{в}+Н_{н})} arch(\frac{2l_2}{\delta_{н}}) \qquad (7)$$

$$\delta_{ср.я} = \frac{\delta_{в}+\delta_{н}}{2} \qquad (8)$$

After this replacement, the calculation is carried out as a homogeneous dam with an overflow drain, as in the previous scheme.

$$\delta_{ср.я} = \frac{0,6+0,6}{2} = 0,6м$$

$$К'_{я} = 0,005 + \frac{2*0,005+0,6}{\pi(23+0)} \; ar\,ch(\frac{2*96.2}{0,6})$$

The value is $ar\,ch(\frac{2l_2}{\delta_{н}})$ the inverse of the hyperbolic cosine function, defined by the logarithmic function: $arch(\text{x}) = ln(\text{x} + \sqrt{\text{X}^2 - 1})$

From here we get:

$$arch\left(\frac{2*96.2}{0,6}\right) = arch(320.67) = ln\left(320.67 + \sqrt{320.67^2 - 1}\right) = ln(639.81) = 6.46$$

Substituting in the formula we get:

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$$К'_я = 0,005 + \frac{2 * 0,005 + 0,6}{\pi(23 + 0)} * 6.46 = 0,059$$

$$\Delta L_я = \frac{18.88}{0,059} * 0,6 = 192м$$

The calculation is made according to the method proposed by prof. Nedriga.VP. [6] c.124.

$$\frac{q}{k_t} = \frac{H^2}{L_p + \sqrt{L_p{}^2 - m^2 * H^2}} \qquad (9)$$

$$\frac{q}{k_t} = \frac{23^2}{288.2 + \sqrt{288.2^2 - 4.12^2 * 23^2}} = \frac{529}{560.38} = 0,944; \quad L_p = 196 + 96.2 = 288.2м$$

Since$m_1 \geq 2$, we take $\beta_B = 0,4$;

$$\Delta L_B = 0,4 * 23 = 9.2 h_B = 4.62 * 0,944 = 4.36м$$

When m1 ≥ 1the value off$f(m_2) = 0.5 + m_2 f(m_2) = 0.5 + 4.12 = 4.62$

According to the data obtained, a depression curve was constructed:

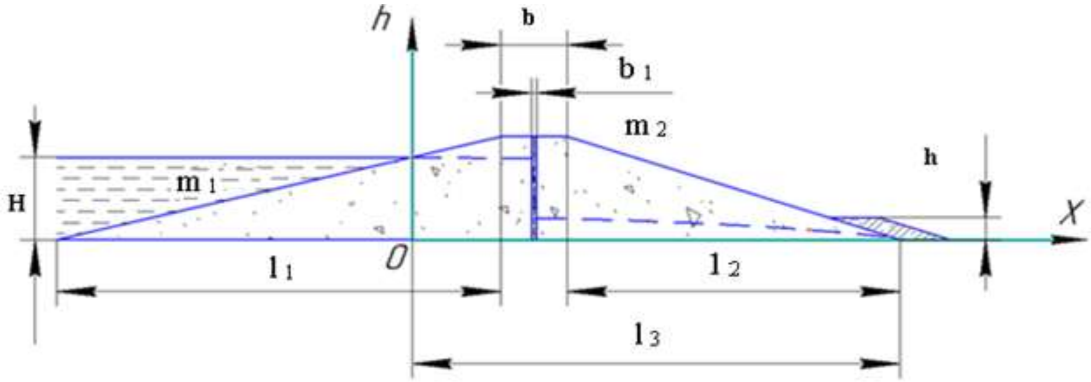

Figure 4

As is known, clay with a high plasticity number of montmorillonite composition (Logonsky deposit) is characterized in natural occurrence by a value of the filtration coefficient not higher than 0.001 ... 0.004 m / day. When laying such lumpy clay in a clay solution as a result of disintegration of lumps and swelling, the value of the filtration coefficient decreases by no less than an order of magnitude. This property of lumpy clay also creates a reserve of safety properties of the anti-filtration properties of the veil.

Thus, the experience of using clay as an impervious screen of the reservoir dam showed its effectiveness.

IV. Results

1. As studies have shown, the filtration strength of the curtain material of the Central Fergana reservoir dam is provided with a maximum pressure gradient of Jp = 35m, which is lower than the minimum value of the initial filtration gradient (35 <40).
2. As a result of a brief review of the literature, it was revealed that in most of its authors the books do not give an unambiguous answer to the question of the presence in the clays of the initial gradient of filtration.
3. Our experimental studies to determine the initial gradient in the clay of the Logonsky deposit showed that it is in the range of 40-70
4. The experience of using clay as an impervious filter curtain of the reservoir dam showed its effectiveness.

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