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Investigation of the interaction of hydraulic parameters of the channel in the filtration process

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Abstract. One of the most important and complex issues in the design of soil drainage channels is the issue of correct accounting of the filtration process. It is necessary to take into account hydraulic parameters and soil composition of existing channels in order to reduce filtration flow rate in ditches with uncoated soil. The article shows how to choose its theoretical basis for reducing the filtration flow rate correctly. Hydraulically convenient design is one of the current problems in the design of canals. This can be achieved by reducing the wet perimeter of the channel to reduce the filtration process in the channel. The article recommends that measures to reduce the filtration process be implemented during the construction or reconstruction of canals, without dismantling and rehabilitating existing canals. Field research was conducted on the North Fergana main canal. In order to study the filtration processes, measurement works were carried out on the PK 396+00, PK 497+01, PK 688+7, PK 692+6, PK 694+6, PK 697+00 pickets crossing the 2-section of the channel in the city of Namangan. In addition, the article developed recommendations on the methods and procedures for the application of bentonite clay from the Lagon betonet clay deposit of the Fergana region to the bottom of the channel in order to reduce the filtration process that occurs in the canal area. According to the results of the study, in the range from PK 411 + 00 to PK 426 + 74, filtration consumption was higher than other pickets.

1 Introduction

Efficient use of water resources is a key factor in environmental protection and socio-economic development.

The growing need for the rational and efficient use of water resources, the rapid development of scientific and technical processes in water management complexes require an in-depth analysis of the formation of the kinematic characteristics of turbulent flow in

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canals, improving the technical condition of existing irrigation systems or building new irrigation systems [3, 4].

Soil canals are artificial engineering structures in which the elements of the flow and the channel are naturally connected by a complex in which the flow develops and controls its own state of the channel [6]. One of the most important and complex issues in the design of soil channels in irrigation systems is the issue of correct consideration of the filtration process [8].

To ensure reliable design and successful operation of irrigation canals, it is necessary to study the patterns of flow changes and the filtration process; the selection and study of a solid cross-section of irrigation canals based on changes in the depth, width, and flow rate is one of the urgent problems of hydraulics [7, 19].

Unnecessary water losses can occur as a result of the filtration process in ditches, rising groundwater levels, flooding and waterlogging of areas, salinization of the soil, causing accidents. It should be noted that the occurrence of these events will reduce the FIC of the canals, require the design of drainage systems and the removal of drainage water, stop the use of restored agricultural land, soil degradation, and wash the banks of the canal in some areas [3].

2 Materials and methods

In Uzbekistan, there are deposits of bentonite clay, rich in various minerals, which are currently widely used in various areas of the republic. The Logon bentonite clay deposit was discovered in 2009 on the territory of the Kuvasay district of the Fergana region and today is considered the second reserve of raw materials for bentonite clay in Uzbekistan [9]. The possibility of using bentonite clay as a waterproofing material was revealed during the construction of structures on the soils of the Fergana region and it can be effectively used as an impervious material.

The content of bentonite clays, montmorillonite in Logon bentonites of the Fergana region varies up to 66%. Other clay minerals are represented mainly by hydromica and insignificantly by kaolinite. Logon bentonite clays are light gray, greasy to the touch, soapy, soft, plastic. Logon bentonites are alkaline [10].

In the ion-exchange complex of clays with alkalinity from 1.26 to 3.14, sodium over potassium and magnesium over calcium sharply predominate; in general they are sodium. Logon bentonite is the second industrially developed alkaline bentonite object in the Republic. Their ability to swell is 200-300% or more; when activated, it increases several times. Bentonites contain a large amount of potassium, phosphorus and more than 10 microelements useful for plants [11,12]. These properties of clays make it possible to widely use them as an ameliorant that saves irrigation water, and later as a natural, environmentally friendly, natural fertilizer - agro-ore in agriculture, primarily in the Ferghana Valley.

In the practice of hydraulic engineering construction, impervious devices made of clay (hereinafter referred to as bentonite) soils (depressions, screens, cores, etc.) have become widespread. When designing them, it is very important to correctly assess the water permeability of the soil. Overestimation of this value leads to cost overruns in the design and waste of material resources, and underestimation - to higher filtration losses. The latter is especially unpleasant for the case of screening industrial waste storage facilities containing hazardous chemicals, the migration of which in larger quantities than expected can cause pollution of the surrounding area and exclude it from economic use for a long time [13,14].

At present, the determination of the filtration coefficient of bentonites is often carried out based on the results of relatively short-term (no more than one month) experiments, which can lead to an indefinite underestimation of their water permeability. With a large area of industrial waste storage facilities (tens and hundreds of hectares) and a significant service life, understating the filtration coefficient even by an order of magnitude is fraught with significant errors in predicting filtration losses with all the ensuing consequences [13, 15].

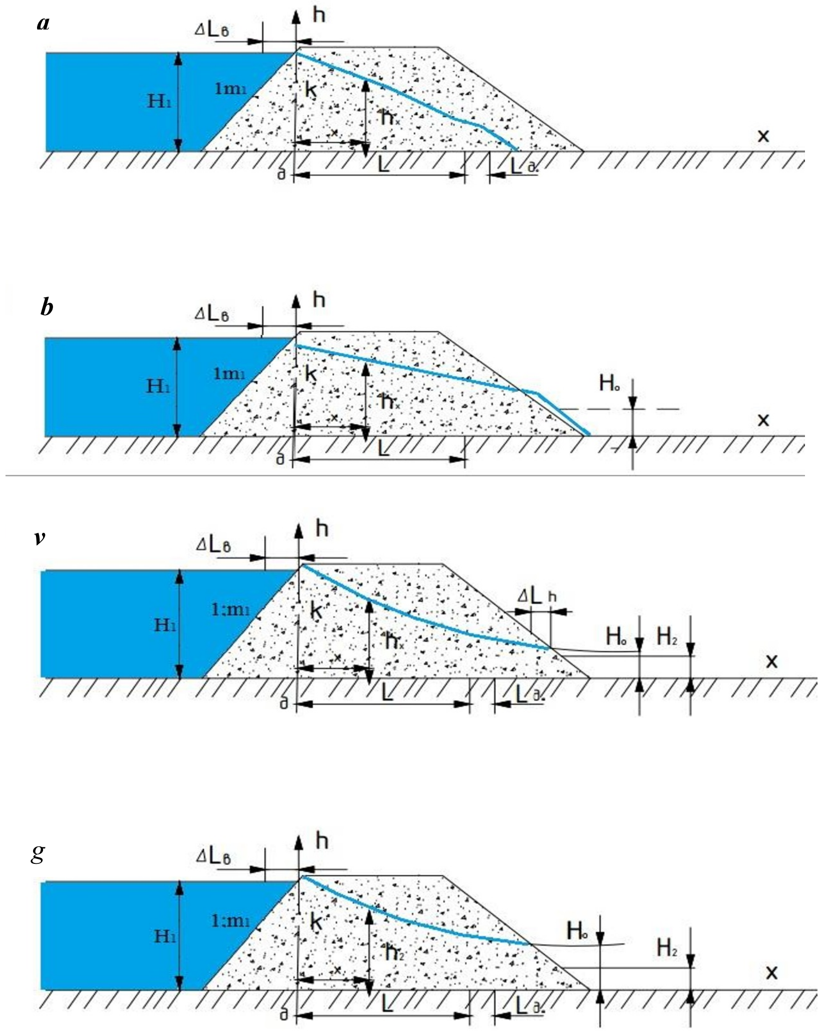

Fig. 1. Schemes of filtration calculations of near-channel dams: *a* - with tubular drainage; *b* – with drainage banquet; *v* – with layered drainage; *g* – in the presence of water in the downstream.

Since the canal dam (Fig. 1) is an ordinary low-pressure earthen dam, then for its filtration calculation, the methods for calculating earthen dams set forth in BR(Building regulations) [12] are fully applicable. For the simplest case of water filtration through a dam made of homogeneous soil on an impermeable base (Fig. 1, a), you can use the formulas given in BR.

It is known that the process of water filtration is observed in soil channels under the action of gravity. The inefficient use of such water for filtration leads to an increase in the cross-sectional area of the canal and an increase in the groundwater level in the area where the canal passes. Currently, due to filtration, the soil loses 50-60% of water in the canals. In the area where the irrigation network passes, groundwater infiltration is considered to be very low. The filtering scheme corresponding to this case is shown in Fig. 1. [1, 2]:

$$q = k(B + 2h\frac{K}{K_1})\left[\frac{m^3}{\sec}\right] \tag{1}$$

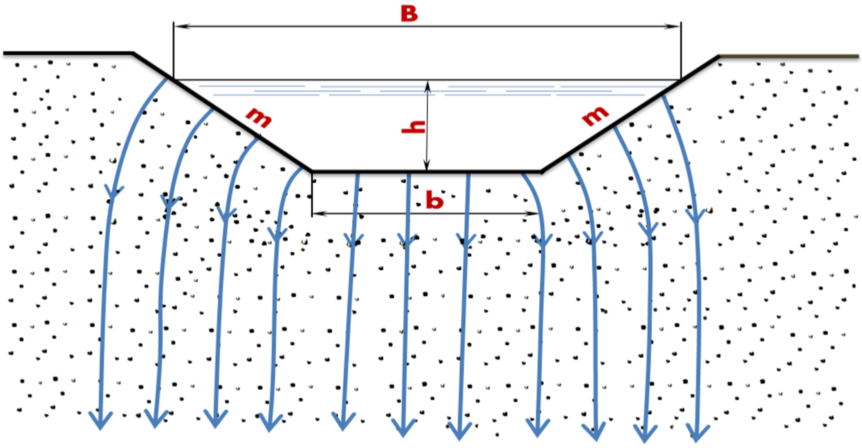

Fig. 2. Scheme of the infinity of water: *k* is the filtration coefficient of the rock forming the channel core, *B* is the channel width above the water level, m, h is the channel depth, m, K and K1 are the first order elliptic integral (1).

We will have:

$$\frac{q}{h} = k\left(\frac{B}{h} + 2\frac{K}{K_1}\right) \tag{2}$$

$2\frac{K}{K_1}$ = A we can write the equation as follows.

$$\frac{q}{h} = k\left(\frac{B}{h} + A\right) \tag{3}$$

where: B is the water level of the trapezoidal channel, $2\frac{K}{K_1} = A = f\left(\frac{B}{h}\right)$ and provided that $B = b + 2mh$.

Using the equation, we have the following expression:

$$\frac{B}{h} = \frac{b}{h} + 2m = \beta + 2m \tag{4}$$

and $\frac{q}{h} = k(\beta + 2m + A)$ we will have $\frac{q}{h}$ the value of *k*=1 can be determined based on the references suggested by the researchers for the situation. But the filtration coefficient is always k=1 will not be equal to [2, 5].

To further improve the computational work, both sides of the last equation were wetted around the perimeter

$$\chi : \frac{q\chi}{h} = k\chi(\beta + 2m + A) \tag{5}$$

here $\chi = b + m^1 h$ or same $\frac{\chi}{h} = \frac{b}{h} + m^1 = \beta + m^1$ if $q = \beta + m^1 = k\chi(\beta + 2m + A)$ or

$$q = k\chi \frac{(\beta + 2m + A)}{\beta + m^1} \tag{6}$$

Thus, we have a relationship between the influencing filtration coefficient and the applied flow perimeter for the filtration flow. Given in Equation (6) $\frac{(\beta + 2m + A)}{\beta + m^1}$ is the slope factor m and $\beta = f(\frac{B}{h})$ acts as a dependent correction factor, i.e.

$$\frac{(\beta + 2m + A)}{\beta + m^1} = \alpha = f(\beta) \tag{7}$$

Using equation (7), we can write the filtration rate as follows:

$$q = k\alpha\chi \tag{8}$$

Equation (8) shows that as the value of the relative channel width increases, the value of the correction factor becomes closer to each other [1, 15-18]. The results obtained from the computational work can be used to determine the value of the correction factor (Figure 3).

From the graph shown in figure 3, it is known that the value of the correction factor in the hydraulically convenient area is almost constant. The relative width of the channel from β in cases with a large value of the correction factor converges together [2].

The theoretical formulas described above for determining the filtration rate in channels correspond more closely to the physical nature of the empirical formulas. However, these formulas do not take into account the influence of local factors and do not fully reflect the physical nature of the filtration process in individual irrigation systems [4].

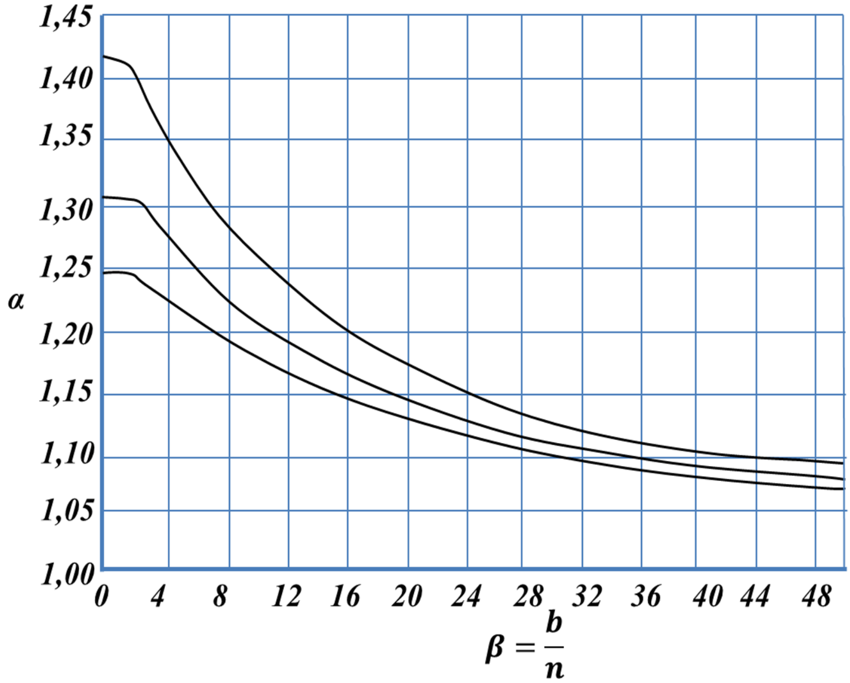

Fig. 3. Graph for determining the value of the correction factor.

To study filtration processes in the North Fergana main canal, PK 396+00, PK 497+01, PK 688+7, PK 692+6, PK 694+6, PK 697+00, PK 1014+80, PK 1130+ 44 , PK 1074 + 80 PK, 1084 + 20 and in the last part the alignments were selected. Water consumption measurements were previously carried out on PK 396+00 (Fig. 4).

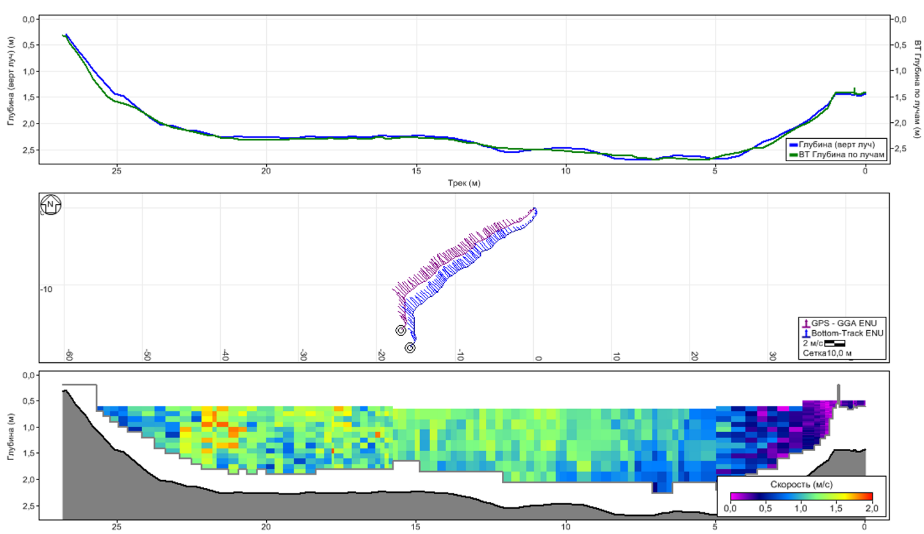

Fig. 4. Results obtained on the Doppler instrument "RiverSurveyor S5/M9 System Manual"

According to the measurement results, the water flow was 50.2 m3/s. At the first post (396+00), the time of water arrival at the second post (PK-437+01) was determined after the completion of measurements. That is, at an average flow velocity of 0.82 m/s, the time for water to reach the next stream reaches an average of 57 minutes. After this time, measurements were made at the second post (PK-437+01). As a result, the measurement of water flow was = 44.6 m3/s. The estimated water flow in this range was 1.8 m3/s. As a result of the measurement, it was found that in the range PK 396+00, PK 497+01=3.8 m3/s, water seeps into the soil in vain. Based on the research, the following designs have been developed for coating an uncoated channel with low-permeability coatings.

In order to protect against filtration of the existing canal during the improvement of the North Fergana main canal PK 411+00 to PK 426+74 from the filtration process it is recommended:

Due to the fact that the bottom of the canal consists of clean soil and sandy-gravel soil, the bottom of the canal is covered with Lagan bentonite clay up to 8-10 cm. At the same time, 16-20 kg of bentonite clay is consumed per 1 m2 of the surface.

1. The understory bentonite cover in the valley is covered with local stone up to 15-20 cm above the surface. The purpose of stone paving can be used to prevent washing out of bentonite clay, as well as to improve the quality of the finish of the canal bed.

2. Gabion mesh 4mm 8*10 cm or 5mm 10*15cm is fixed with steel pile 15-20cm over undergrowth bentonite clay and stone pavement in the valley. This condition prevents slippage of the stone cover and damage to the structural design of the canal wall.

3. Swelling of bentonite clay leads to filling of the pores. Bentonite clay also serves as a tree nutrient as a mineral fertilizer based on its chemical composition. It is possible to re-examine this coating during the subsequent reconstruction of the canal. Depending on the operation process, bentonite gabion cover can be used as an impervious measure for 8-10 years.

4. Since the concreting of the canal base is not included in the project, it is necessary to soften the canal base by 10-15 cm. -15 cm with a cultivator. The softened surface is re-sprinkled with bentonite clay at the rate of 4 kg per 1 m2 up to 2 cm and a screed is made using the available technical machines. Given that the length of the clogging channel is 0.1-1 km, the water velocity in the channel during the clogging period will be 0.05-0.20 m/s, and the water velocity in the channel during operation will be 0.6 - 0.7 is recommended m/s. This method reduces the filtration process in the canal by 80-90%.

3 Conclusions

In conclusion, we can say that it is possible to achieve a reduction in the size of the applied perimeter to reduce the filtration flow in the bed of the channels, i.e. the channel should be designed in a hydraulically convenient section. Of course, this does not mean the demolition of existing channels and their restoration. These measures are recommended to be taken during the planned reconstruction of canals. It is necessary to take into account the composition of the soil of existing channels in order to reduce the flow of filtration in channels with uncoated soil. The reduction can be achieved by using cost-effective methods to reduce seepage in soil channels.

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