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Designing and Calculation of Canal Mounting Attachments under Conditions of Variation of Ground Water Level

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ABSTRACT:The article discusses new design solutions for securing the slope of workers working in conditions of changing groundwater level. The calculation method for determining the number of filter cups providing the necessary strength of the lining and the stability of the slopes of the canal is given.

KEY WORDS: main canal, filtration, slope laying, cladding, concrete, reinforced concrete, channel slope fastenings, filter cups, groundwater level, slope stability.

I.INTRODUCTION

In the practice of operating the main canals, deformations of the bases were observed, as well as local violations of the stability of the slopes of the lined and unclad channels. Often, a violation of stability led to accidents.

Typically, canal routes pass in recesses of various depths, in various engineering-geological and hydrogeological conditions. Initially, the groundwater level in these areas is below the canal mark. Therefore, the task at the first stage of operation of structures is to eliminate filtration losses from the channel. Subsequently, due to infiltration from upstream canals, reservoirs and irrigation of adjacent territories, groundwater is fed and groundwater levels may rise above the channel mark.

Obviously, this situation can lead to adverse consequences, especially with a rapid decrease in the water level in the channel. At the same time, significant hydrodynamic pressures of water, which can cause the destruction of slopes, will have to act on the cladding. Therefore, the study of the protection of the canal lining from the effects of these filtration waters is of great practical importance.

The most reliable fastenings of canal slopes in similar conditions are those that under normal conditions of the canal operation, when there is no backwater from the groundwater side, the lining should exclude filtration from the canal, i.e. filtration losses of irrigated water, and in the presence of backwater and with a rapid decrease in the water level in the canal, it should provide free exit of the soil flow into the channel of the canal or its diversion to the other side. This eliminates the occurrence of significant hydrodynamic pressures, and the destruction of the fastenings of the slopes of the channel.

As shown by the experience of operating the main channels of Central Asia in the fastenings of slopes, crack formation and destruction of the lining under the influence of weighing filtering pressure took place.

II. METHODS OF RESEARCH

Therefore, in order to ensure the reliability of the fastening on the perception of the main loads acting on the cladding, at their most advantageous combination, various designs of filter cups are adopted. A known design for attaching slopes of canals and pressure-bearing earthen reservoir dams, including a monolithic concrete lining, filter cups built into it, with protruding heads closed by metal covers freely fitted on them (with a gap) and containing filters made of gravel and sand material in fiberglass bags . This design works in the following sequence. When the water horizon in the channel is higher than the level of groundwater, the valve cover is pressed to the outlet, which prevents leakage of water from the channel. If the groundwater level in the channel exceeds the groundwater level, the valve cover opens due to the pressure difference, and the groundwater enters the channel, thereby reducing the hydrostatic pressure on the slope.

The disadvantages of this mounting design include the inability to prevent water leakage from the channel through the gaps between the cover and the pipe in the head, which leads to significant water loss from the channel during its operation in the absence of groundwater under the lining.

We have developed a new design of the cladding with filter cups and obtained a patent of the Republic of Uzbekistan [1], which allows for an organized output of filtration water when the water level in the upstream reaches the desired flow rate from under the concrete cladding to its surface and reduce the weighting pressure of the water on the cladding to permissible values and exclude suffusion in soils. These conditions must be provided with sufficient sizes of glasses and their quantity in the area under consideration. The exclusion of the suffusion of the material of the slope body is ensured by the correct selection of the material of the glass filters.
Fig. 1 shows a structural diagram of the mounting of the slope of the channel, in Fig. 2 the design of the filter cup (node I).

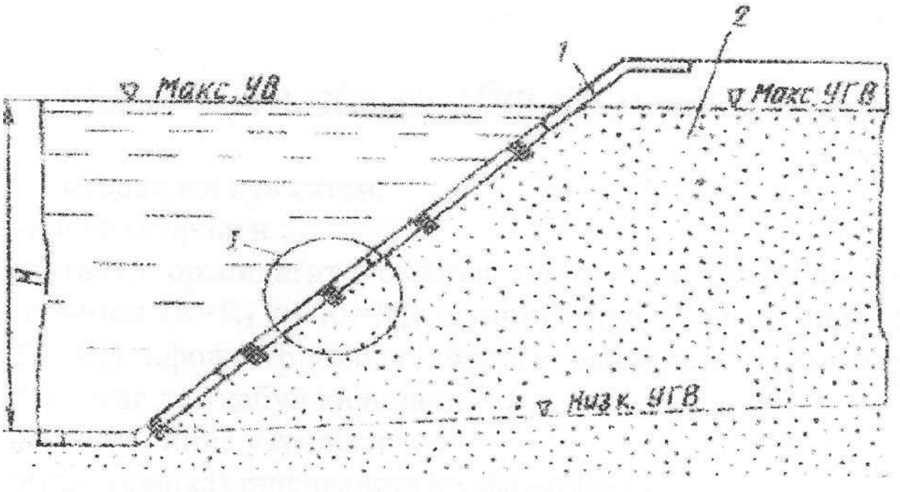

Fig. 1. Structural scheme of fastening the slope of the channel:
1-concrete monolithic slab; 2- sandy soil of a slope; 3- filter cups.

The fastening design is a cladding of concrete monolithic slabs 1, laid on prepared sandy soil of slope 2, with filter cups minted into it (node A).

The design of the filter cup consists of two main parts: a tubular filter and an impermeable head. The tubular filter is a polyethylene pipe 3 with perforations 4 in its lower part, sheathed with filter non-woven synthetic material 5 of the type Dornit or fiberglass. A head 6 of a polyethylene pipe with a cork 7 of a sand-bitumen mixture (asphalt) is insulated on the upper part of the pipe, isolated from its inner part with a parchment gasket 8, which reduces friction.

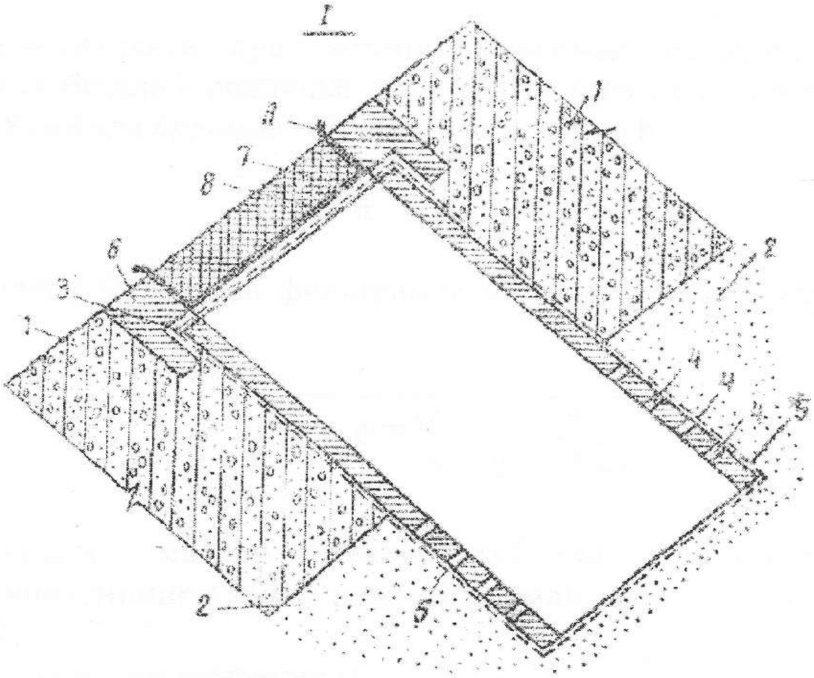

Fig. 2. The design of the filter bowl:
1 concrete slab; 2- slope ground; 3-polyethylene pipe; 4-hole punching; 5-filter made of dornite or fiberglass; 6 - the tip of the glass; 7-cork from sand-bitumen mixture; 8- glassine pad.

The design of the slope mounting works as follows. In the initial period of operation of the canal with the maximum level of filling (Max. HC) and in the absence of groundwater under the lining (Low. UHV), it should be waterproof and exclude water loss from filtering from the channel. This is achieved by the fact that the filtering openings of the glasses from above in the head are hermetically closed by an impermeable asphalt plug.

In the subsequent period of operation of the canal, associated with the rise of the groundwater level to its highest state (Max. UHW), when the maximum filtration head weighing the lining is achieved with a quick discharge of the level and complete absence of water in the canal (H = 0), the fastening should ensure general and filtration stability of soil slope. This goal is achieved by the fact that under the influence of the filtration pressure the waterproofing plug is automatically pushed out of the hole of the nozzle of the cup and ground water quickly leaves the plates, through them into the channel, reducing the filtration pressure. The free exit of the cork from the head is ensured by a glassine coating that reduces its friction in the pipe. The arrangement of holes in the lower part of the pipe, buried under the lining in the protected slope soil, increases the surface of the water intake zone of the filter, increases the flow rate through the glass, and provides a quick decrease in pressure on the cladding from the plates. Subsequently, the filter cups operate as usual with minor losses or inflows of groundwater into the channel. The filtration strength of the slope, the exclusion of siltation of the glasses and the prevention of mechanical suffusion are ensured by synthetic filters.

Filtration glasses on pressure slopes should be arranged in the zone of fluctuation of the water level in concrete cladding, provided there is no engineering exit of the filtration stream at the bottom of the slope.

The number of filter cups in the channel section is set based on the stability of the cladding plates. Two groups of glasses are installed across the channel — the left and its right sides with a step of height h. The step of installing the glasses in height should not be more than the permissible difference in the water levels under the lining and the channel h, which is established from the condition of stability of the plates when the moments of all forces are equal with respect to the upper rib and the condition of ultimate balance of forces is observed according to the dependence [2]:

$$h^3 + 3(H_1 - lsin\alpha)h^2 + 3H_1(H_1 - 2lsin\alpha)h + [2(R_1 + R_3) + Gcos\alpha]lsin^2\alpha = 0 \quad (1)$$

where H_1-is the water level in the channel above the lower end of the plate; G is the weight of the plate; R_1 and R_2 are the resultant of elementary resistance forces in the plate joints (since R = R_2 and R_3 = R_4, then in (1) the total value of these forces is taken into account by expression 2 (R_1 + R_2). It is taken to be 10% of the weight of the plate; l is the length of the plate across the channel; f is the coefficient of friction of the plate on the ground (film); α is the angle of inclination of the slope (plate) above the horizon.

The number of installed glasses n in one diameter of the channel in the left and right slopes is calculated by the formula:

$$n = \frac{2(H_c - h_0)}{h} \qquad (2)$$

where $\mathbf{H_c}$ is the maximum depth of the water level in the channel; $\mathbf{h_0}$— installation height of the first cup in the slope above the channel bottom levels, taken within the permissible value of **h** calculated according to (1).

The distance between the diameters of the nearest groups of glasses is established from the condition of not exceeding the permissible value of the weighing filtration head hc in the center

$$h_c = h \qquad (3)$$

The filtration pressure between the diameters of the glasses is calculated by the dependence [3]

$$h_c = \sqrt{H^2 - 0{,}73\frac{Q_c}{k}\ell g\frac{R}{0{,}5\sqrt{a^2 + \text{в}^2}}}\ , \qquad (4)$$

where H- thickness of the aquifer of the sand massif above the level of the bottom of the channel (H≈ H_c);

R- radius of influence of the group of glasses adopted for the sand massif R≈ 200m;

K – sand filtration coefficient;

Q_c –group flow rate ($Q_c = \sum Q_p$)

в – the distance between the groups of glasses in one diameter.

Filtration flow through the filter cup: a) with a flat bottom end is calculated according to [3]

$$Q = 4kr_0(H_c - h') , \qquad (5)$$

b) with a filter perforated at the bottom, it is calculated according to

$$Q = 2\pi kr_0(H_c - h') \qquad (6)$$

wherer_0-radius of glass;

H_c – the pressure of water on the cladding at the point of installation of the glass;

h' - water level in a glass.

An example of calculating the number of glasses in a channel lining.

Initial data. The main channel 77 km long lies in the sand massif with a filtration coefficient K = 8 m / day. The width of the channel along the bottom B = 20m, the depth of filling and discharge of water H_c= 7m, the laying of slopes m = 3. The fastening design is a cladding of monolithic plates of size ℓx in x δ = 6 x 3 x 0.15, laid directly on the sandy slope. Filtration glasses are installed in groups in the cross section of each diameter of n pcs in the left and right slopes starting from a height h_0 = 0 m from the bottom surface.

Filtration glasses have an internal pipe diameter of 0.3 m. In the end lower part of the pipe is made with perforation and covered with fiberglass. When minting glasses in a slope, the filter part is planted in the protected soil.
It is required to determine the number of glasses across and along the entire length of the 77km channel.
Result. We determine the step of installing glasses across from equation (1), having previously found its components: H_1=0, sinα=sin(arctg1/m)= 6·3·0,15·2,5= 6,75 ((volumetric mass of concrete γ = 2.5 t / m^3), the sum of the reactive forces in the joints of plate 2(R_1 + R_2)= 0,1G=0,675t. when setting the obtained values, expression (1) takes the form

$$h^3 – 5.69h^2 +12.74=0 \text{ from where } h = 1.81 \text{ m}.$$

The number of glasses in the profile on the left and right slopes will be

$$n = (2 (7-1)) / 1.8 = 6.6$$

We take rounded 8 glasses, for $n_y = 4$ in each group, set with a step of h = 1.75 m in height.

We determine the flow rate of water through the glasses. Since the glasses in the lower part have a volumetric filter, the flow rate is calculated taking into account the sphere of water inflow according to the formula (6) at different pressures for each of the 4 glasses of the same group H_c= 1.75; 3.5; 5.25 and 7m. Accordingly, for each of the glasses, the flow rate will be

$$Q = 2\pi 8 \cdot 0.15 H_c = 13.2;\ 26.4;\ 39.6;\ 52.8\ \text{m}^3/\text{day}$$

The filtration pressure between the diameters of 4 groups of 4 glasses in each set is set by constructive value **a**. We initially accept the distance between the diameters of the glasses **a** = 20 m.

The distance between two groups of glasses in one diameter is calculated by the formula:

$$в = mH_c + \text{B} = 3 \cdot 7 + 16 = 37\text{m}$$

The total consumption of 4 groups of glasses in two diameters is

$$Q_h = 4\, Q_y = 527.9\ \text{m}^3/\text{day}$$

Substituting the known values in (4), we have

$$h_c = \sqrt{7^2 - 0{,}73\frac{527{,}9}{8}\ell g\frac{200}{0{,}5\sqrt{20^2 + 37^2}}} = 1{,}37\ \text{м},$$

Which is less than the permissible value h = 1.81 m.

III.CONCLUSION

Consequently, the set value "a" is accepted correctly.
The number of glasses for the entire length of the channel will be

$n = 2n_y \frac{L}{a} = = 2 \cdot 4\ 77000/20 = 30800$ pieces.

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