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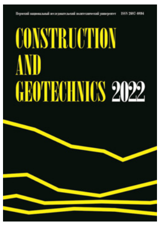

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ANALYSIS OF THE STABILITY OF THE KUBAN RIVER LANDSLIDE SLOPE INVOLVING THE MATERIALS OF LANDSLIDE HAZARD MONITORING

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ABSTRACT

The article discusses the improvement of methods for calculating the landslide threat in the monitoring of landslide hazard areas on the Kuban River and the study of the possibility of their negative impact on the operated hydraulic structures. The growth of economic activity, intensive use of water resources in the Kuban River basin leads to a decrease in the bearing capacity of slopes and an increase in landslide phenomena. These processes are also observed in the basins of other anthropogenically developed rivers of the Russian Federation. Shore protection structures and their construction are justified on the basis of the limit state method in accordance with the requirements of SR 58.13330.2011. The stability of such structures should be determined by reference to the stability conditions of the entire slope taking into account all acting loads and impacts. To solve this problem it is very effective to use a complex of structures regulating the flow of the river, flow guides (dams made of selected rockfill), slope-strengthening ones, etc. Measures justifying economic activity on a landslide slope are very effective. The right slope of the Kuban River in the suburbs of Armavir, Krasnodar Krai is characterized by the fact that significant (more than 3 m) fluctuations in inter-level and flood flow of rare frequency are observed on this section of the river. Realizing anti-landslide and bank strengthening measures it is necessary to provide for both a reduction in general and local erosion of the left bank and the drainage of groundwater and surface from the anthropogenically developed area adjacent to the right slope of the river Kuban.

The purpose of this research is to substantiate the stability of the right slope of the Kuban River in the vicinity of the city of Armavir, Krasnodar Krai, where initial collapses are already taking place in connection with the construction of residential buildings in the immediate vicinity of the bank and the development of general and local erosion of the right bank of the river. The calculation is carried out according to several methods for the basic and special load combinations. These calculations are necessary to substantiate landslide and bank protection measures on the right bank of the Kuban River.

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АНАЛИЗ УСТОЙЧИВОСТИ ОПОЛЗНЕВОГО СКЛОНА РЕКИ КУБАНИ С ИСПОЛЬЗОВАНИЕМ МАТЕРИАЛОВ МОНИТОРИНГА ОПОЛЗНЕВОЙ ОПАСНОСТИ

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АННОТАЦИЯ

Рассмотрено совершенствование методов расчета оползневой угрозы при мониторинге оползнеопасных участков на р. Кубани и исследование возможности их негативного воздействия на эксплуатируемые гидротехнические сооружения. Рост хозяйственной деятельности, интенсивное использование водных ресурсов в бассейне р. Кубани ведет к снижению несущей способности склонов и росту оползневых явлений. Эти процессы отмечаются и в бассейнах других антропогенно освоенных рек Российской Федерации. Берегозащитные сооружения и их конструкции обосновывают на основе метода предельных состояний в соответствии с требованиями СП 58.13330.2011. Устойчивость подобных сооружений следует устанавливать исходя из условий устойчивости всего склона с учетом всех действующих нагрузок и воздействий. Для решения поставленной задачи эффективен комплекс сооружений: регулирующих сток реки, струенаправляющих (дамбы из каменной наброски), склоноукрепяющие и др. Весьма эффективны мероприятия, обосновывающие хозяйственную деятельность на оползневом склоне. Правый склон р. Кубани в окрестностях г. Армавира Краснодарского края характерен тем, что на этом участке реки отмечаются значительные (более 3 м) колебания меженного и паводкового расхода редкой повторяемости. При реализации противооползневых, берегоукрепляющих мероприятий необходимо предусматривать как снижение общего и местного размыва левого берега, так и отвод поверхностных и подземных вод с антропогенно освоенного района примыкающему к правому склону р. Кубани. Целью исследований по данной работе является обоснование устойчивости правого склона р. Кубани в окрестностях г. Армавира Краснодарского края, где уже имеют место начальные обрушения в связи со строительством жилых зданий в непосредственной близи с берегом, развитием общего и местного размыва правого берега реки. Расчет проводится с использованием нескольких методик для основного и особого сочетания нагрузок. Данные расчеты необходимы для обоснования противооползневых и берегоукрепительных мероприятий правого берега р. Кубани.

Introduction

A landslide should be understood as an unstable mass of soil that shifts along a slope. According to the Ministry of Emergency Situations of Russia about 40 % of the territory of this country where 60% of Russian residents live is landslide-hazardous due to the conditions of erosion and geological features of the area. 725 (70 %) of 1036 cities in Russia are affected by landslides and landfalls. The direct average annual damage in the Russian Federation from landslides is more than 10 billion rubles. So, to reduce damage from landslides more than 3 billion rubles are spent annually in Russia [1, 2]. In the south of Russia 60 % of the territory of the Karachay-Cherkess Republic, 53.5 % of the territory of the Republic of Adygea and 28.5 % of the Krasnodar Krai Territory are classified as very dangerous due to landslide processes, i.e. interregional and federal emergencies in these territories are possible. Landslides are widespread on the banks of reservoirs and rivers, especially in the Siberian and Far Eastern Federal Districts [3].

On the steep right-bank slope of the Kuban River bend, within the urban development of Armavir city, Krasnodar Krai, the process of river (lateral) erosion is developing, which is intensified by the man-made impact on the geological environment. The main factors in the development of this process are geological, geomorphological, meteorological conditions, and anthropogenic activity. At the present stage the main reason for the development of an unfavorable process is the construction of buildings and structures in landslide-prone areas, which has led to the changes in the coastline, erosion of the right steep bank and slope and intensification of unfavorable engineering and geological processes - landfalls, sloughs, landslides [4, 5].

In the northern part of the work site, the bed of the Kuban River is cut into floodplain alluvial deposits, as a result of which there is erosion of sediments in the riverbed, there is no erosion of the bank. In the south-eastern southern part, there is a steep coast, where the loose deposits of the second alluvial terrace above the floodplain are subject to erosion and destruction. In high water the sands lying on the loam are washed away. In the low-water period, there is physical weathering and collapse of loams coming out on the day surface, as a result of erosion of sand deposits lying underneath. Such type of the river bank processing creates prerequisites for the development of landslides; the sandy alluvium of the second terrace above the floodplain begins to slide along the loam moistened with groundwater [6].

Further development of river erosion and other accompanying unfavorable engineering and geological processes can become dangerous and requires the implementation of anti-erosion measures to prevent dangerous processes [7, 8].

Methodology of the research

The purpose of the field survey was to study the engineering-geological and hydrogeological conditions of the territory for the developed project documentation, taking into account the requirements of the current regulatory documents. The basis for the preparation of the report was the materials of the previous years studies, field research, laboratory and office work [9].

At the research site to study engineering and geological conditions based on materials from studies of previous years (2017) [15–16], 4 profiles were passed: 3 profiles along the slope (perpendicular to the coastline), one profile along the coastline. Distance between profiles 125–700 m. Taking into account the detailed study of the area under consideration three years ago, in addition to verifying the reliability of the surveys of previous years, it is planned to drill the V section, consisting of 4 wells with a depth of 4.5 to 8.0 m with a distance between workings from 10 to 12 m, while reducing the distance between workings in sections IV-IV, along the bank of the Kuban River, from 125–700 to 125–400 m (Fig. 1).

Fig. 1. Washing out sandy soil at the base of the slope
Рис. 1. Подмыв песчаного грунта у основания склона

Laboratory tests of soils related to the determination of granulometric composition, water-physical, structural properties and characteristics of rocks, chemical analysis of water, were carried out in a stationary laboratory in compliance with the requirements of regulatory documents [10]. Office processing of field and laboratory work included the materials from the studies of previous years, the construction of engineering and geological sections, drill columns, and the formation of tables [11].

During a route survey of sections of the right bank within the urban development of the city of Armavir, Krasnodar Krai, located close to the edge of a steep slope, it has been observed an intensification of erosion processes which progresses every year. The main residential development is located from 5 to 15 m from the edge of the slope. It is almost impossible to get there by transport due to the fear of a landslide. The slope is steep up to 45°, littered and in some places reinforced with available materials: slate, tires, boards, etc.

Residential buildings do not have a centralized sewerage system; fecal water is discharged into cesspools, through which the water is filtered and has a great impact on the rise of groundwater and, consequently, on the water content of slope sediments composed mainly of sands.

The southern outskirts of the city have a steep slope from the edge to the Kuban river water line up to 40–45°, further to the northwest towards the boat pier it flattens out to 20–25°. The slope of the right bank of the river Kuban is turfed and forested in places - in the south with willow, and upstream – with ash and maple.

Further downstream, the slope is steep, abruptly ending at the water's edge with a ledge composed of loam. There is an outcrop of gray-green loam with a ledge height of up to 0.5 m and a gradual increase in height downstream to 3–4 m.

Fig. 2 shows a recorded landslide with a separation wall of 1.5–2.0 m from sandy soils, which came down along with the trees, 270 m to the south along the stream, in a section of 100 m. Currently it is observed the remains of trees with uprooted roots. The sliding plane for landslides is gray-green, hard loam. Groundwater in the area under consideration lies at a depth of 13–13.5 m and is discharged into the river Kuban. In some areas, they are observed to come to the surface near the water's line.

Fig. 2. View of the Kuban River in the alignment of the landslide slope
Рис. 2. Вид на реку Кубань в створе оползневого склона

The geological structure involves two structural levels separated by a sharp angular unconformity: the lower Precambrian crystalline basement and the upper Phanerozoic weakly disturbed platform cover. In describing the geological structure rocks which lie above the level of the modern hydrographic network are characterized, i.e. these are deposits of Quaternary and Devonian age.

Quaternary system:

– technogenic formations (tQIV) – modern formations represented by a mixture of sandy loam, chernozem, chalk chips, slag and construction waste, with a thickness of 0.3–1.3 m [12];

– soil-vegetation layer (pdQIV) – modern formations represented by sandy loam chernozem, thickness 0.2–0.5 m;

– modern alluvial formations (aQIV) are represented by sands from grayish-yellow to gray, quartz, medium-grained with rare inclusions of up to 5 cm of gray clays, water-saturated in the lower interval of the layer 2.6–3.2 m [13];

– Upper Neo-Pleistocene alluvial deposits (aQ^2III) are represented by yellow, grayish-yellow, quartz, medium-grained sands, weakly watered in the lower interval of the layer 0.3–0.5 m, the thickness is 13.0 m;

– Upper Neo-Pleistocene alluvial loams (aQ^2III) are represented by greenish-gray loams, heavy, with inclusions of limestone pebbles, 2.5 m thick;

– Upper Neo-Pleistocene alluvial sands (aQ^2III) – yellowish-gray to gray, quartz, medium-grained, in the lower interval of the layer with pebbles and limestone boulders, water-saturated, thickness 9.5 m [14].

Devonian system:

– Stary Oskol Complex (D3st) – grey, silicified sandstones [15].

The hydrogeological conditions of the survey site are characterized by the presence of groundwater confined to the deposits of the Upper Quaternary age; up to a depth of 25 m, the following aquifers are identified:

– perched water of the Upper Quaternary complex, the water-bearing rocks are medium-grained sands, the depth of occurrence is 0.3–0.9 m, the thickness of the aquifer is 0.3–0.4 m. Penetrated by wells 7, 16, 17.

– the aquifer Upper Quaternary alluvial horizon (aQIII) is confined to the deposits of the second floodplain terrace of the Kuban River. The water-bearing rocks are medium-grained sands in the upper part to coarse-grained sands with gravel, clay and sandstone boulders in the bottom. The horizon is low-pressure. There is a close relationship with the underlying Sargaev-Semiluki aquifer carbonate complex. The aquifer is recharged by infiltration of precipitation, river runoff during the flood period, as well as inflow from other aquifers. Unloading occurs in the Kuban River and the underlying horizons.

Based on the results of engineering and geological surveys 5 engineering and geological elements were identified in the soil thickness explored to a depth of 8 m [16]:

1) Holocene technogenic deposits (thIV) are a mixture of sandy loam, chernozem, chalk chips, slag and construction debris, with a thickness of up to 1.3 m.

2) Holocene soil-vegetation layer (pdIV) – sandy loam chernozem, 0.5 m thick.

3) Holocene + Upper Pleistocene alluvial deposits ($aIV+a^2III$) – yellow, grayish-yellow to gray sands, medium coarseness, medium density, low humidity, up to 22.0 m thick.

4) Upper Pleistocene (a^2III) – greenish-grey loams with limestone pebbles, hard, up to 2.2 m thick.

5) Upper Pleistocene (a^2III) sands of yellowish-gray to gray, of medium size, at the end of the interval of the layer with pebbles and sandstone boulders [17].

The basis for the design of the structures is the sands and loams of engineering and geological section EGE –3, 4.

Groundwater during the survey period was discovered in well 18 at a depth of 2.3 m and in well 19 at a depth of 3.1 m. Groundwater belongs to the aquiferous Upper Quaternary alluvial horizon (a2III), the water-bearing rocks are alluvial sands EGE –3, 5. Steady level of groundwater is 2.5–13.5 m. Water is low-mineralized (1.07–1.33 g/l), hydrocarbonate-sulfate and non-aggressive to all brands of cement.

The soaking capacity of EGE –4 loam is very slow, according to laboratory data it is less than 25 % of the volume in 24 hours.

In the process of office processing survey materials from previous years were studied and systematized [18] and carried out by present surveys (2017) along the V-V section. The composition and physical and mechanical properties of the soils are similar and no significant deviations are observed, so no additional research is required.

Categories of soils according to the difficulty of development with an excavator (according State Elemental Estimate Standards for Construction Work 2001):

– alluvial sands (EGE -3) – 36b;

– alluvial loam (EGE -4) – 35b.

According to Set of Rules 14.13330.2018 seismic-soil conditions correspond to the second category in terms of seismic properties. The estimated seismic intensity of the site is 7 points (provided that the object is assigned to map C according to General Seismic Zoning 1997) [19].

The soils forming the right bank of the Kuban River in the vicinity of Armavir city, Krasnodar Krai, are weak to the impact of water flow, at high speeds of which, more than 0.6 m/s, the dynamic equilibrium of the geological environment is disturbed, and this leads to the development of landslides and lateral erosion. Therefore, it is necessary to carry out bank protection works in this area.

Taking into account the fact that all methods of stability analysis have different assumptions, the results will be different with a fairly large spread in values. Therefore, in order to find the minimum slope stability coefficient it is necessary to perform calculations using several methods and then compare the obtained values.

Let us determine the values of the design load and soil characteristics for a given landslide slope of the river Kuban. The stability of slopes and falls is influenced by a huge number of factors: geometric parameters (angle of slope β and its height H), physical and mechanical properties of the soil mass (c – adhesion coefficient, φ – angle of internal friction, γ – volumetric weight of soil, ξ – lateral pressure coefficient), external load parameters (q – intencity, b – width, z – vertical coordinate of the middle of the load diagram, applied to the surface of the slope).

In order to obtain dependencies between the factors determining the load-bearing capacity of the slope and the stability safety factor prof. A.N. Bogomolov performed calculations of the quantity K_{st} for computational schemes [20], in which the angle of the slope β modified from 20° to 35°, the intensity of the reduced vertical uniformly distributed load is equal to $\frac{q}{\gamma H} \in [0-6]$, its reduced width is $\frac{b}{H} \in [0.05-0.6]$, reduced vertical coordinate of the middle of the loaded area is $\frac{z}{H} \in [0-0.65]$. The value of the coefficient of lateral soil pressure in the calculations was taken equal to 0.3; 0.5 and 0.75, and the physical and mechanical properties of the soils varied within such limits that the value of the reduced cohesion pressure was $\frac{\sigma_{cs}}{\gamma H} = c(\gamma \mathrm{Htg}\varphi)^{-1} \in [0-10]$.

The following relationships have been determined:

1. At the value of the reduced sutface load intensity $q > 0,05$ the numerical value of the lateral soil pressure coefficient does not affect the position and shape of the most probable slope failure surface and the value of the corresponding stability safety factor. Therefore, all further calculations were carried out at one value $\xi = 0,75$, which corresponds to clay soils.

2. For all considered values q, b, z, β the relation $K = f(\sigma_{cs})$, strictly speaking, it is not linear, but can be approximated by a straight line with a sufficient degree of accuracy.

3. The relation of the type $K = f(q)$ at fixed values of connectivity pressure has a clearly nonlinear character. For external load intensity values within the range $q \in [0-6]$ it can be described by an exponential curve.

4. He position of the load affects the stability of the slope as follows. When changing coordinates z from 0, when the load is directly at the upper edge of the slope, up to 0.5, all other things being equal, the value of K_{st} will decrease by approximately 20–25 %. With further increase z the stability factor increases. There is a simple explanation for this: bringing the loaded area closer to the horizontal surface of the base of the slope gradually "turns off" the difficult terrain factor from the work.

5. An increase in the load width at constant load intensity from 0.1 to 0.5 reduces the value of the slope stability coefficient by 40–55 %. A further increase has virtually no effect on K_{st}, as in this case the load also approaches the base of the slope which, as in the previous case, leads to an increase in stability.

Analysis of the above research results shows that the dependence of the stability coefficient is very complex and its exact determination for the entire variety of design schemes is practically impossible. However, prof. A.N. Bogomolov managed to obtain an approximating formula connecting the intensity of a vertical uniformly distributed load acting on a slope with the value of the stability safety factor:

$$K = d\left(1.05 + 0.1e^{-b^*}\right)\left(1 + 0.2e^{-z^*}\right)\left(1 + a\sigma_{cs}\right)\text{tg}\varphi, \quad (1)$$

where $b^* = \dfrac{10b}{H} - 2$; $z^* = \dfrac{10|z|}{H}$ are given calculated values of the load width and the vertical coordinate of the middle of the loaded area; a and d – coefficients defined as functions q and β on diagrams; e – base of natural logarithms.

Basic load combination: $H = 22{,}13\,\text{m}$, $\varphi = 32°$, $c = 0.7\,\text{kPa}$, $\gamma = 15.97\,\dfrac{\text{kN}}{\text{m}^3}$, $\beta = 27°$, loading $q = 20$ kPa, $z = 8.5$ m, $b = 41.5$ m.

Given calculated parameters of external load and physical and mechanical properties of soils: $b^* = 16.7$, $z^* = 3.84$, $\dfrac{q}{\gamma H} = 0.05$, $\dfrac{\sigma_{cs}}{\gamma H} = 0.003$, $\text{tg}\varphi = 0.625$.

Numerical values of coefficients a and d, found from the graphs for the calculated value q and slope corner β, are correspomdingly equal to: a = 3.7, d = 2.65. By substituting the found values into the formula for determining the stability factor, we get:

$$K = 2.65\left(1.05 + 0.1e^{-16{,}7}\right)\left(1 + 0.2e^{-3.84}\right)\left(1 + 3.7 \cdot 0{,}003\right)0.625 = 1.8.$$

Special load combination: $H = 23.05$ m, $\varphi = 30°$, $c = 0.7$ kPa, $\gamma = 19.75\,\dfrac{\text{kN}}{\text{m}^3}$, $\beta = 27°$, loading $q = 20\,kPa$, $z = 8{,}5\ m$, $b = 41{,}5\ m$.

Given calculated parameters of external load and physical and mechanical properties of soils: $b^* = 16.0$, $z^* = 3.68$, $\dfrac{q}{\gamma H} = 0.04$, $\dfrac{\sigma_{cs}}{\gamma H} = 0.0026$, $\text{tg}\varphi = 0.577$.

Numerical values of coefficients a and d, found from the graphs for the calculated value q and angle of slope β, are correspondingly equal to: $a = 3.6$, $d = 2.75$. By substituting the found values into the formula for determining the stability factor, we get:

$$K = 2.75\left(1.05 + 0.1e^{-16}\right)\left(1 + 0.2e^{-3.68}\right)\left(1 + 3.6 \cdot 0.0026\right)0.577 = 1.7.$$

Let us perform a stability calculation taking into account seismic loads, since $\mu = \frac{\pi}{4} - \frac{\varphi}{2} = 29°$, then the stability calculation is carried out according to the scheme in Fig. 3.

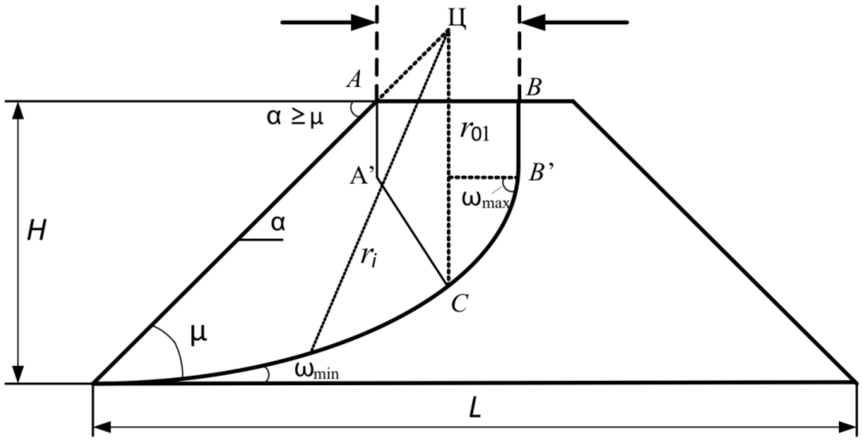

Fig. 3. Scheme of the formation of a landslide in a slope
Рис. 3. Схема формирования оползня в откосе

The sliding surface is constructed in the following order:
– determine the thickness of the elastic layer, m:

$$H_{90} = \frac{2C}{\gamma}\ \mathrm{ctg}\mu = \frac{2 \cdot 0.7}{15.97} \cdot 1.8 = 0.157,$$

– define the zero radius vector, m:

$$r_0 = \frac{H\mathrm{ctg}\alpha\left(\mathrm{tg}\alpha + \mathrm{ctg}\mu\right) - H_{90}}{\left(\mathrm{tg}\alpha + \mathrm{ctg}\mu\right)\cos\alpha \cdot e^{\left(\frac{\pi}{2} - \alpha\right)\mathrm{ctg}\mu}} = \frac{22.13 \cdot 1.96\left(0.509 + 1.8\right) - 0.157}{\left(0.509 + 1.8\right) \cdot 0.891 \cdot e^{1.98}} = 6,75.$$

– determine the width of the landslide prism a_0, m:

$$a_0 = \frac{2(r_0 - H_{90})}{\mathrm{tg}\alpha + \mathrm{ctg}\mu} = \frac{2(6.75 - 0.157)}{0.509 + 1.8} = 5.71,$$

– setting zenith angles ν_i equal to 10, 20, 30, 35, 40, 45, 50, 55, 61, 5 and $\nu_{\max} = \frac{\pi}{2} - \mu = 61.5$ determine the length of the corresponding radius vectors using the formula: $r_i = r_0 \cdot e^{\nu_i \mathrm{ctg}\mu}$.

Height of the filtration flow outlet to the bottom slope, m:

$$H_0 = \left(\frac{L + \Delta L_B}{m_2 - 0.5}\right) - \sqrt{\left(\frac{L + \Delta L_B}{m_2 - 0.5}\right) - H_1^2\left(\frac{m_2 + 0,5}{m_2 - 0.5}\right)} = 4.0.$$

Ordinate Point *K*, m:

$$h_K = H_1 - \frac{q}{K_T} = H_1 - \frac{K_T H_0}{\left(m_2 + 0.5\right) K_T} = 15.$$

and its corresponding abscissa x_K is determined from the equation, m:

$$x_K = \frac{\left(H_1^2 - h_K^2\right)\left(L - H_0 m_2\right)}{H_1^2 - H_0^2} = 39.$$

After constructing the surface of the filtration flow the body of potential landslide is divided into vertical compartments with a width of $b = 4$ m, in each of which the height of the compartment above is measured $\left(h_с\right)$ and below $\left(h_в\right)$ depression curve and sliding surface inclination angles $\left(\delta_с\right)$ and filtration flow $\left(\delta_в\right)$ (Fig. 4).

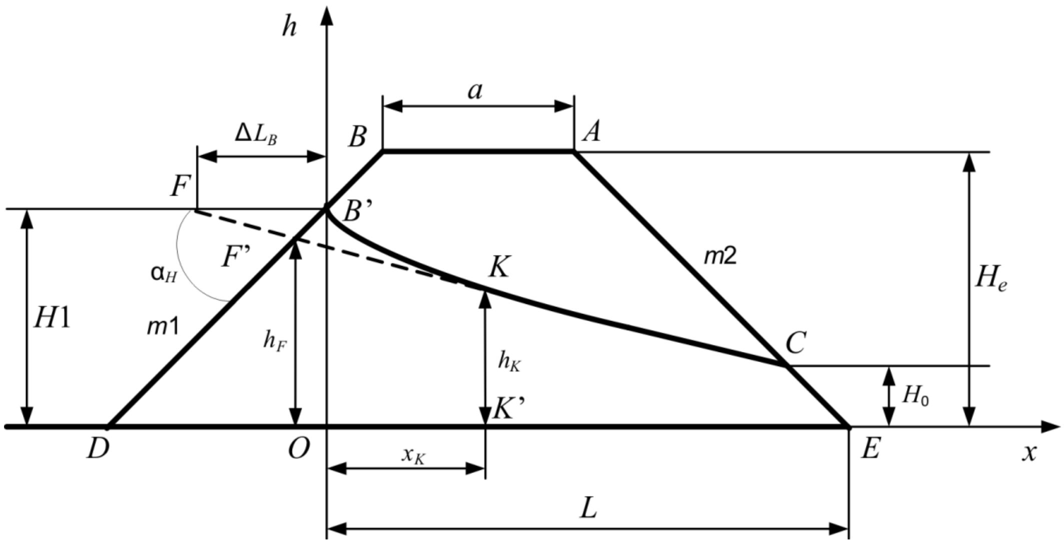

Fig. 4. Scheme for calculating the drawdown curve in the slope
Рис. 4. Схема к расчету кривой депрессии в откосе

Volumetric weight of soil in the flooded part of the slope γ_{sb} is taken to be equal to:

$$\gamma_{sb} = \left(\gamma_s - \gamma_0\right)\left(1 - n\right). \quad (2)$$

The weight of the compartments is determined as the sum of the weight of the surface and underwater parts:

$$G_i = b(\gamma_s h_с + \gamma_{sb} h_в); \quad (3)$$

length of sliding surface at the base of the compartment:

$$l_i = b \sec \delta_{ic}; \quad (4)$$

and the shear force produced by the filtration flow:

$$T_{iв} = b\gamma_0 h_{iв} \sin\delta_{iв}. \quad (5)$$

The stability factor is determined by the formula:

1. Basic load combination:

$$n = \frac{\sum G_i \cos\delta_{ic} \operatorname{tg}\varphi + b\sum C \sec\delta_{ic}}{\sum G_i \sin\delta_{ic} + b\gamma_0 \sum h_{ib} \sin\delta_{ib}} = 1{,}1.$$

2. Special combination of loads:

$$n = \frac{\sum G_i \cos\delta_{ic} \operatorname{tg}\varphi + b \sum C \sec\delta_{ic}}{\sum G_i \sin\delta_{ic} + b\gamma_0 \sum h_{ib} \sin\delta_{ib}} = 1.0.$$

Conclusion

Landslides occur both on natural slopes and on man-made structures. The increase in landslide activity is significantly associated with anthropogenic human activity. According to the international statistics the origin of about 80 % of modern landslides is related to human activity.

Among the most well-known landslides note should be made of the following ones:

– the collapse of the Panama Canal embankment (1915), which led to the necessity of excavating several tens of millions of m^3 of soil;

– the collapse of the embankments in Gothenburg (Sweden) in 1916 which caused a wide range of works by the Swedish geotechnical school (there were examined more than 2400 cross-sections and natural slopes);

– a landslide in the Philippines in 2006 which killed 1.126 people (according to the International Disaster Bank).

In Russia about 40 % of the country's territory where 60 % of RF population lives is subject to landslides. Substantiation of the degree of stability of landslide-prone areas is one of the most important tasks of geotechnics. Currently, more than 100 different methods are known for calculating the short-term and long-term stability of slopes and downhills.

Assessment of the stability of the right landslide slope of the Kuban River within the urban development of Armavir city, Krasnodar Krai, by various methods indicates the need for landslide prevention measures. The most reasonable should be considered the assessment made with the use of the normative method recommended by Set of Rules 39.13330.2012 "Dams made of soil materials". Stability Factor of the Landslide Slope of the Kuban River for the Basic Combination of Loads is $k_{st} = 1.17 < k_{acc} = 1.15$, for special combimation of loads is $k_{st} = 0.99 < k_{acc} = 1.04$.

The own weight of the landslide slope fastening with the use of structures (according to Sevkavgidroproekt options) has a negligible effect on reducing its stability.

Numerical calculations of the stability of the right landslide slope of the Kuban River within the urban development of Armavir city, Krasnodar Krai by the the finite element method showed a high sensitivity of the slope to dynamic and seismic loads.

Correct determination of the soil strength characteristics is the key to a reliable assessment of landslide slopes stability. It is necessary to pay special attention to the procedures for measuring these characteristics in engineering and geological surveys ensuring the reliability of the results obtained.

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