

Question about risk assessment of landslide process origin

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Abstract. In the article, the events that may occur during landslides and their consequences are analyzed. Information was provided on risk assessment and determination of risk results in the prevention of landslides.

Keywords: *landslides, risk; analyzing*

1. INTRODUCTION

The results of landslides occurrence monitoring suggest that they are actively manifested on about 40% of the ravine, and 70% of the river slopes of southern Russia. Often, negative slope processes are the result of anthropogenic and technogenic influences and they appear in places where in natural conditions without any stimulus their appearance is simply impossible. Special alarm and anxiety activation of slope processes cause when this occurs near various pipelines, large chemical facilities, nuclear and hydroelectric power stations, waterworks and other open-pit mining industries. In this case, active slope processes pose a serious threat to ecological and economic security of the government. In this context, the problem of reliable slopes estimation for the slope processes control in order to minimize the probabilities of an emergency situation appearance and reduction of the corresponding risks is of obvious urgency.

Purpose

Under the reliability of slopes estimation their ability to perceive the totality of external factors - stress, climatic, technological and human factors - during a specified period with ensuring of normal operation located on the slopes of the buildings and farmland should be understood.

2. THE BASIS FOR RELIABLE ESTIMATES OF THE SLOPES

The basis for reliable estimates of the slopes should be the results of engineering-geological surveys that provide information, most of which are not explicitly regulated by the latest regulations. They are:

1. Information about geomorphologic features of the territory, including engineering and geological sections, height data, horizontal equivalent of the slopes, the sides of slopes and dams. It is necessary to carry out the grouping of the earth's surface according to the likeness of geomorphologic features of the relief items and their relative age, because such sites will have approximately the same range and power of rock of geological-genetic complexes, the degree of weathering, natural relaxation of stresses approximately equal probability of occurrence of slope, suffusion processes and effects of drawdown.

2. Information about stratigraphic features of rocks within the study area. It is necessary to pay attention to the similarity in the context of genetic or litho-petrographic rock types in the same degree modified by weathering processes, suffusion, loading and unloading, and other man-made factors.

3. Information about hydrogeological characteristics of reclaimed areas: the degree of water content in rocks, nutrition and drainage conditions of subsoil water and groundwater, their man-caused pollution and chemical composition. It is necessary to collect reliable data about the number of groundwater and subsoil water horizons; their deposit depth; diversion of drained water conditions; water pressure; down gradient of the piezometric levels; leaching of aggressiveness to the rocks, and their admixtures, cement and metals; the content of carbonate, sulfate and iron compounds; carbon dioxide-free.

4. Data on the climatic conditions of reclaimed areas, including the number of at a time rainfalls; depths of soil watering during the periods of heavy rains; depth of seasonal freezing of soils.

5. Information about the presence in the area hazardous natural and manmade processes occurring into paragenetic series, along with landslides; conditions of their activation; appropriate set of protection engineering measures, etc.

Given the amount of the aforesaid information above, and the fact that soils themselves are complex multiphase disperse systems, we can conclude that the creation of a single universal computational model that adequately describes the stress-strain state of the ground mass of complex geometry and suitable for engineering practice is almost impossible.

When analyzing and determining the reliability of natural slopes and landslide structures, as well as for soil bases the following features may be used: the basic provisions of the mathematical theory of multi-element reliability of technical systems applied to structural mechanics solving problems; methods of slope stability and landslide retaining structures to limit state calculation; methods of deformation and stability of the slopes calculation (I and II limit states) with taking into account the construction properties of soils as natural multiphase medium; statistical and probabilistic methods for physical and mechanical properties of soil slopes assessing, slopes and earthworks as a natural geological formations.

3. MATHEMATICAL RISK

Mathematical risk theory is based on the use of methods of mathematical statistics and probability theory. Into the theory basis the claim that any slope is possible manifestations of landslides or avalanches, i.e., there is a risk of partial or complete loss of stability is laid [1].

Risk is calculated for the unknown events that are very likely to happen; the degree of probability can be estimated.

Quantitative risk assessment is often coincides with the probability rate for simple tasks, which allows with a greater degree of accuracy to solve a complex problem in technical terms. For example, using of risk theory with a high degree of reliability numerical values of the dynamic parameters underlying the calculation of the slope safety factor, taking into account the intensity of seismic action are determined. On this basis, in the risk theory an approximate solution of the problem of estimating the influence of random external forces and the random nature of the changes in physico-mechanical properties of the soil in the slopes and the slopes of the design of anti-structures is given.

To determine the likelihood of a landslide it is necessary to set the initial and boundary conditions that correspond to this phenomenon.

The main factor determining the solution of the soils stability in their natural state problem, is analyze of loosening and changes in humidity effect. In the shear zone the structure of clay is disturbed and reoriented, at the same time a decrease in shear resistance is happen[2].

The calculation of the stress-strain state of soil mass should be performed by numerical methods taking into account the above remark.

Method is based on a statistically sound value of an imminent risk to which the slope in the specific context is undergone. To assess the risk period of time during which the slope shall be stable is set. The second factor is the importance (category) of the slope, which is defined as a function of flow rate on the recovery of the damage that may occur as a result of the landslide. As a general rule, risk increasing

reduce the costs on measures of slope strengthening, but at the same time a landslide may occur before the estimated time [3].

For different parts of slope the expected risk will be different. For the best solutions event-stabilizing measurements over the slope are distributed. Target function is made and by conventional methods of optimization work cost to strengthen the soil mass is determined.

4. RATIONAL METHOD

The most rational method for determining the reliability of the slope coefficient is a statistical method of calculation using the theory of risk.

Consider the example of the slope stability analysis, for which possible slip surface roughly parallel to the surface [3].

For the main parameter characterizing the resistance, we take the intensity of water logging and increase of pore pressure.

In the process of landslide moving pore pressure changes, as well as the coefficient of friction between the landslide and the stable part of the slope.

For determination of the calculated intensity of the landslide vital importance plays the period of repeatability (cyclic process). For large-scale landslide the period of repeatability is greater than for small, so the probability of occurrence of large landslides and the destruction of the object with a low-life will be low, respectively, risk level decreases.

At the same risk degree for the object, located within the expected landslide, we calculate the intensity of the estimated value of the expected benefits.

The objective function $E|U|$ determine from the expression:

$$E|U| = E|B| - E|C| - E|D|,$$

where: $E|D|$ - generalized expected value of damages; $E|C|$ - generalized expected value of the original buildings in the zone of the landslide; $E|B|$ - generalized expected revenue from the operation of facilities.

The initial cost of construction is defined as a deterministic value by the following formula:

$$C_i = A_{0i} + A_{ri} Y_{si}^{ni},$$

where: A_0 - the cost of construction without strengthening of the slope costs; A_r - factor that determines the cost of landslide events; Y_s - estimated intensity of the landslide.

After the transformation

$$Y_s = (r K D_0 / n y A_{11})^{1/(n+r)},$$

where: K and r - numerical coefficients, r - risk, $K = \text{const}$; D_0 - damages cost.

The risk scale includes the probability of failure rates: intangible - 10^8 , little - 10^{-7} , low - 10^{-4} , the high - 10^{-3} .

With the increase in «intensity» of the landslide or damage cost, i.e. with increasing of K or D_0 , the intensity of the estimated risk increases; the increase in costs for stabilizing measures, i.e. increasing of n and A_r , the calculated intensity of the risk is reduced.

5. CONCLUSION

In many structures not only bearing structures can be damaged, but some elements (for example, coating), which can be easily restored. For these elements the intensity of the landslide can be divided into two parts, Y_1 and Y_2 (for the primary and secondary systems).

$$Y_1 = [r (D_1 - D_2) / n_1 y A_{11}]^{1/(n_1+r)}; Y_2 = [r D_2 K / n_2 y A_{12}]^{1/(n_2+r)},$$

where r - risk degree; D_1 - damage cost; y - relative percentage of repayment costs; n - the mean number of damage per unit time.

In both formulas, the degree of risk (r) is taken equal in magnitude.

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