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Methods of regional zoning of territories by zones with the risk of landslides

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Abstract. one of the most important parts of the general complex for studying the regime of landslide processes are geodetic measurements of the development of landslide displacements. Therefore, the justification of the necessary accuracy of geodetic measurements, the choice of the method of such observations and the development of technology for their implementation should proceed from the principle of obtaining the most complete and reliable information about the landslide slope. This article is the result of studying the possibility of using geodetic systems in the research of landslide processes. Methods of investigation of the stress-strain state of rocks of the landslide slope are considered. There are many options for building maps of dangerous areas. The advantages and disadvantages of each method are described.

1. Introduction

It is common knowledge that land zones are the zones for which the rules of use are determined in accordance with the approved regulations and with the purpose (attribution) of the area as a place for particular type of activity. In this article the authors will try to consider the versatility of the methods used to determine the boundaries of the area of the zone affected by landslide processes.

To choose the method of zoning of the area of landslide processes, it is necessary to define the terminology. Thus the term "landslide" implies the geological process of displacement of soil masses. It should be noted that this term is often used to describe (define) a landslip, mudflow, talus, creep (slow and constant sliding of loose soil along the slopes of the relief). One of the main issues in determining the methods of zoning of landslide processes is to identify the mechanism of landslides' formation and development, i.e. the engineering-geological conditions under which landslides are observed. The landslide process occurs under the influence of gravitational body forces, seismic forces, seepage pressure, natural-technogenic and deformation-time load. On totality of the impact of all these processes, according to the nature of the disturbance of the balance of the soil body and the peculiarities of deformation, landslides can be divided into three main types:

- block, frontal compression-extrusion landslides (the predominant mechanism for the development of deformations when the landslide is formed is the gravitational compression of the deforming horizon under the weight of the body's covering layers);

- shift -slip landslides (the predominant pattern for the formation and development of deformations in the body is the shift (cut) of the coating weight along the inclined top of the bed-rock, along the bedding planes, along the weak interlayers and the slip of unbalanced soil masses from steep cliffs;

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- liquefaction-flow landslides; in this case the landslide-forming factor is the force impact of groundwater, which causes an increase in pore pressure in the soils with partial or complete liquefaction and the displacement of water-saturated soil masses down the slope.

E.g., on the banks of the Volga, Sok, Samarka and other rivers block, frontal compression-extrusion landslides are the most widespread type on platform terraces.

The type of landslide and the mechanism for the development of deformations in the soil body is the main factor for evaluating the state of the researched area and for determining the degree of landslide hazard for the engineering facility, for the design and implementation of a set of measures to stabilize the steady state of the slope and prevent the development of landslide deformations. It should also be taken into account that the landslide will not form out of the blue. There should be the right conditions for that. One of the main reasons for the formation of landslide processes is heavy load on rock. In most cases this is a result of the construction of facilities on unstable soils. The more is the weight of the object, the more is the load on the ground. In addition the constant impact of natural and technogenic loads, e.g. wind or moisture, leads to the destruction of the rock.

2. Another section of your paper

An example of a frontal landslide is Batrak sidehill, located on the slopes of the Volga Upland between the three thoroughfares near the city of Oktyabrsk (formerly Batraki) in the Syzransky District of the Samara Region. The first railway line (Morshano-Syzranskaya railway) was laid within the boundaries of the district in 1874, and its construction revealed a section with soft collapsing (unstable) soils, and since 1926 periodic monitoring of landslide formations on Batrak sidehill has been carried out.

Taking into account the possible occurrence of landslide processes, before the start of design and construction it is obligatory to perform engineering surveys for a comprehensive study of the natural conditions in the area on the basis of approved GOSTs, SNiPs and rules (SP 446.1325800.2019 Engineering and Geological Surveys for Construction. General Rules for the Production of Work. GOST 5180-2015 Soils. Laboratory Methods for Determination of Physical Characteristics.) The main purpose of such surveys is to determine the area of possible occurrence and development of landslide processes under the influence of areal and linear structures or their parts, both all over the researched area and in its separate parts, after the object is constructed and put into operation. For these purposes the following information is most often used: results of previous engineering-geological and engineering-geodetic surveys, local monitoring data, information about the natural conditions of the area contained in the Federal state information system for land-use planning and in the information systems for ensuring urban planning activities supported by state and private funds. Various-scale map materials are requested (geological, hydrogeological, tectonic and other maps of scales 1: 1000000-1: 200000 and larger), materials of special hydrogeological and engineering-geological mapping and other regional studies, Earth Remote Sensing (ERS) materials, including aerospace photographs of areas. All the above-mentioned studies taken together are the basis for geotechnical regionalization and further land zoning of the area.

If we go back to the example given above, i.e. to the landslide processes taking place on Batrak sidehill, the following can be pointed out. The topographic and geodetic service created by the administration of Morshano-Syzransky (Kuibyshev) railway in the 1930ies prepared topographic plans and longitudinal sections of scales 1: 500 - 1: 2000, which served as the basis for the development of projects for the creation and further development of a special geodetic network. Along the railway line ground reference marks were laid in aggregate, which formed a railway reference mark network (or a special-purpose network) based on the points of the state geodetic network. The reference mark system served as an excellent tool for controlling the geometric basis of railway lines. From its points, by means of traditional geodetic measurements using theodolites and levels, the first sedimentary reference marks

(marks) were laid on Batrak sidehill, also second-order traverse was developed (this work was done by Giprodrev Institute, 1966-1967), which made it possible to perform the initial (zero cycle) observation of sedimentary processes in the area.

Landslide slopes have got relief forms peculiar only to them, their boundaries and forms showing their original or typical character. The relief of the entire surface of such a slope is often uneven. The indicator is the steepness of the slope, as such landslide processes occur more often in mountainous areas or in hilly areas, in addition the steepness of the slope affects the characteristics of landslide processes, their intensity and direction.

Considering the above, traditional methods of geodetic measurements, for example longitudinal horizontal leveling can not always allow predicting or identifying the “imminent” landslide, its direction and temporal intensity. In this regard photogrammetric methods, such as photo-theodolite survey, contribute to a more local, point zoning of the areal landslide process.

Thus the photo-theodolite survey carried out on Batrak sidehill in the 1980ies allowed revealing the deformation of the roadbed and preventing the landslide process that could lead to the destruction of the railway line.

At the same time this method does not allow comprehensively studying the landslide process, since it does not take into account many factors that affect it, for example morphological characteristics.

Currently, with the advent of global digitalization into our lives, traditional methods of studying landslide processes must be used as input material (one of the layers) when creating a digital terrain model (DTM). The digital terrain model allows systematizing, comparing and analyzing the entire layer-by-layer attributive information database, i.e. the entire information cloud, both layer-by-layer and as a complex. The DTM allows not only identifying the imminent landslide processes, but also ranking them according to the degree of danger.

It is common knowledge that different topographic products are used as the basis of the DTM, from orthophotoplans and to materials obtained as a result of Earth Remote Sensing (ERS) (satellite positioning and space photography). It is the use of spectrozonal space photographs that has once again allowed revealing and preventing the deformation subsidence and the landslide process at the railway line in the area next to Batrak sidehill..

3. Results and discussions

The accumulated experience of multifaceted research using geodetic methods and methods based on fundamental geodesy (space geodesy) made it possible to apply the DTM together (combined) with the geographic information system (geographic information system, GIS) - a system for collecting, storing, analyzing and graphically visualizing spatial (geographic) data and the related information about required objects. The developed method allowed not only patenting two inventions and obtaining certificates of state registration for the database "Geoecological system for analyzing the ecological situation in the Samara Region", but also performing the land zoning of the Samara Region, including the main parameters (air, water, soil) distributed according to zones and degree of danger.

4. Conclusions

To sum up all the above-said, it is safe to say that a comprehensive study of the processes occurring on the Earth, including landslides, based on geodetic observations allows the most complete, timely and reliable land zoning for any ranking.

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