SURVEYING OBSERVATIONS OF THE DEFORMATION OF SLOPES IN PITS

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Abstract: *To the article the prevention of landslides and collapses of slopes at quarries, as well as development of measures to reduce harmful impact of deformations of ledges, sides, dumps and territories adjacent to quarries, is a prerequisite for uninterrupted operation of the mining enterprise.*

Keywords: *mining-and-geological terms, surveying, instrumental observations, measures, wall deformation, vertical and steep occurrence, micro deformations.*

The earth's surface above the goaf is in a state of displacement. The process of shearing distinguishes a period of dangerous deformations. The purpose of surveying observations is to establish the boundaries, type and rate of deformation of rocks of the near-edge massif, determine the critical value of displacements, and predict the development of deformation over time during the operation of a quarry to the design mark. For the organization of mine surveying observations, observation stations are installed, and the level of training of mine surveying engineers and practical skills in work, and deep knowledge in the field of the theory of mine surveying are also of great importance. Observation stations consist of points of a high-precision geodetic network and separate profile lines along which working benchmarks are laid. Profile lines are laid in areas where there are factors that reduce the stability of the sides. The length of the observational profile lines is set in such a way that at the maximum depth of the quarry, part of the benchmarks remains in the non-deformable zone. [1].

Under unfavorable conditions of development during the construction of a quarry, the technical design should provide for projects of instrumental observations of the deformation of the sides of the quarry as a whole and of the deformations of individual sections of the quarry [2-4]. The project is compiled by the geological surveying department (service). The drafting of observation stations and the methodology for conducting instrumental observations are based on the following provisions:

1) the occurrence of collapses and landslides is preceded by long-term micro deformations of the near-edge massifs, which makes it possible, based on the results of observations, to judge the nature and degree of danger of possible rock deformations and take measures to prevent them.

2) instrumental observations should be accompanied by a study of the geological structure of individual areas.

3) the reasons for the occurrence of a landslide contribute to the graphs of the change in the displacement rates of the benchmarks along the line and individual characteristic benchmarks, which make it possible to establish the active part of the landslide massif and determine the influence of time and climatic conditions.

4) the materials of instrumental observations should contribute to the possibility of establishing the optimal angles of inclination of the side with a lower safety factor.

5) the data of mine surveying observations should contribute to the timely identification of the nature of the deformation that has begun, which makes it possible to make predictions regarding its development in time and space.

6) take measures to eliminate the causes contributing to the development of the described deformations.

7) the project of observation stations should consist of a plan for the location of the initial, working and reference benchmarks, a brief explanatory note and sections along the profile lines.

8) the project for the construction of observation stations is approved by the chief engineer.

All types of quarry wall deformation are associated with a change in the natural stress state of rocks caused by mining.

Carrying out mine workings increases the unevenness of the all-round compression of rocks, which leads to an increase in tangential stresses in the near-edge zone of the rock mass, often reaching extreme values, resulting in the appearance of landslides and the collapse of the walls of open pits.

For a reliable assessment of the degree of danger of developing deformations, the allowable limits of displacements of the edge array and critical displacement rates for various engineering-geological conditions and types of landslides are preliminarily established. The need to conduct mining operations on deformable sides arises due to errors made in assessing their stability and designating overestimated parameters of the sides, the detuning of which during mining operations leads to the occurrence of cracks and pins, the development of velocities and values of displacements of the near-edge massif close to critical.

The procedure for conducting mining operations and methods of mine surveying control over deformation with a bead massif in a near limit state depends on the mining and geological conditions of open pit operation [13].

With horizontal and flat bedding of rocks in the absence of pins and cracks, the following mining procedure is recommended when extracting additional mineral reserves:

With an increase in the displacement rate to 3–4 mm/day, work on the lower horizons should be stopped until the end of the unloading of the upper part of the side.

When the angle of inclination of the side of the lying side is less than the angle of dip of the rock layers of the near-edge massif, the sequence of mining additional reserves and lower ledges of the sides consists in making control profiles corresponding to the contour of the planned phased mining of the lower ledges and observing the deformation of the sides along these profile lines.

At the same time, the intensity of mining operations decreases at the beginning of displacements of the near-edge massif. Mining operations are stopped when visible cracks and pinholes appear on the surface, outlining a potential slip prism. When the rocks strike diagonally relative to the wall and the dip angle of the layers is equal to or less than the wall inclination angle, the deformations develop along weak contacts and manifest themselves in the form of cracks on the surface and thrust cracks on the surface of the slopes long before the limiting state of the near-edge massif.

As the height of the wall or the angle of inclination of the walls increases, the cracks expand and propagate deep into the massif, while the thrust cracks on the slopes increase and propagate down the ledges of the wall. The rate of crack opening during the development of the lower ledges can reach 200 mm/day, and the total displacement of the upper edge at the time of complete failure of the wall can reach 3–5 m.

At steady displacement rates (along the profile lines) of 5–10 mm/day, mining operations in the lower part of the wall stop and force the unloading of the upper ledges until the wall is given an angle of inclination, at which the margin of stability of the wall increases from the initial one by 20–30%.

Further mining operations in the lower part of the side are carried out with daily control of the displacement rates of the pierced prism [14].

With a vertical and steep occurrence of a layered near-edge massif, in the sections of the sides parallel to the strike of the rocks, the deformations manifest themselves in the form of cracks on the surface of the formation of steps long before the limiting equilibrium.

The magnitude of critical deformations that determine the moment of stopping mining depends on the angle of inclination of the side and its purpose. The values of critical deformations are determined by the values that do not have a harmful effect on transport communications and ensure the safe movement of vehicles along the ramps.

At steep angles of inclination of the side (more than 30°), limiting deformations are limited by the degree of destruction of the surface layer of rocks, the possibility of detachment and rolling of individual pieces and blocks of rock down the side, creating a danger to operating personnel and mining equipment.

In all cases, the state of the board should be considered critical if the stratification of the massif has spread in the upper part of the board and is at least 2/3 of the board height in height.

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