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TODAY'S MEASURES TO IMPROVE THE RIGIDITY OF SLOPES

One of the main problems of mining companies is to ensure safe mining operations at maximum technical-economic indicators. Maximization of steep slopes of quarries and dumps' sides is important when resolving the issue of these indicators increase. However, the question of mines safety is very important here, as far as the disturbance of the rock mass balance can result in landslides. First of all, it concernsthe alluvial deposits. The increased rigidity of mine workings is necessary to prevent. The necessary level of rigidity is achieved by applying landslide measures.

Currently, there are many ways to improve the rigidity of slopes: the application of geolattices, anchoring, and fastening via Gabion, various concrete and wooden structures.

Recently, the ways to increase sustainability using lattices and ground anchors are considerably spread abroad. But, a partial lack of recommendations, in particular on the geometrical parameters of strengthened zones, structural elements and their place in amassif, and these elements' impact on the increasing of slopes rigidity was discovered while studyingscientific publications, literature and the recommendations of the manufacturer.

It is possible to make some conclusions about the features of such devices as geolattices and ground anchors when studying official sources of such manufacturers as "LLC Evroyzol Heosyntetyks", "OJSC 494 UNR", "LL Heozahyst», «Foresight Products LLC».

Geo lattices that have a high chemical resistance are madeof environmentally friendly polyethylene and polypropylene material. Such lattice can take the load of at least 40 kN/rm. The durability of such construction is more than 50 years. The lattices are placed mainly on soft rocks, the rigidity of which is significantly affected by water saturation. Geolattices are used both for local, and for general sustainability (placement in layers). Consolidation is performed with v - shaped reinforcing rods. It enables to fill the non rigid steep slopes with special material. The lack of the rigidity of the collapseprisms is one of the disadvantages.

Self-opening ground anchors are used for tensile load. They are divided into three types: Duckbill (2,6-28 kN), Manta Ray (72-178 kN) and Stingray (445 kN). Installation of the first two types can be performed manually using a jackhammer. The installation of the anchor Stingray is performed by the excavator with a hydraulic hammer. Amongthe advantages of such anchors are: the accurate placement; the possibility of placement in less accessible spaces; the ability to test load capacity immediately after the installation. However, the problem is a small bearing surface (up to 2400 cm^2) which, in turn, is important when fixing slopes surface. First of all, it concerns soft rocks. Such rocks can "bypass" the anchor.

The technology of the injection anchor is initially carried out by drilling a given diameter.The draft anchor with reinforcing rods, including two injection tubes is established next. Then, a drilling hole is filled by a concrete mixture. A few days later, one more portion of a concrete mixture is filledthrough the second tube. It is necessary for pressing anchor bottom. When the anchor gets strengthened, its tension can be increased with a jack.

Consequently, assessing the advantages and disadvantages of these methods, some conclusions can be made. Geo lattice and soil anchors can be used incombination. Geo lattice copes well with the local soil fixation and soil anchors provide rigidness of slopes with deep slip surface. The absence of sufficient information on the combined use of these methods is the issue for discussion.

Since the calculation to determine the rigidity is labor-intensive, geotechnical software GEO5 was used to carry out the research.

Observations of the geometric parameters change to provide berm security were conducted when searching the optimum angle of slopes inclination. A board with a height of 15 m was taken for investigation. The calculations were carried out in different variants of the berm security placement. The board was divided into two terraces: I – bottom and II – top, with the security berm between them. There were 6 variants selected for calculations: 1) I – 3m and II – 12 m; 2) I – 6 m and II – 9 pm; 3) I – 9m and II – 6 m; 4) I – 12 and II – 3 m; 5) I – 7,5 m and II – 7,5 m; 6) I – 15 and II – 0 m. The results are shown in Table. 1.

Table. 1

Number var.	1	2	3	4	5	6
I-II, c.	3-12	6-9	9-6	12-3	7,5-7,5	15-0
α,degree	29.26	29.15	29.18	29.12	29	28.73

According to the study results, it was found out that security berms do not increase the rigidity of isotropic rock slopes. The reason is that forincreasing angles of terrace slopes by reducing the height it is necessary to increase the minimum security berm to a sufficient level.It is necessary to ensure the rigidity of the entire board.

A series of calculations to determine the optimal angle of inclination of the ground anchor and the optimal site for its location have been performed.

The angle of the anchor inclination, at which the coefficient of the board margin is the largest, was determined. There were two boardswith different characteristics selected for the experiment: I – the height of 10 m, and II – 15 m. A security berm was also placed on the board of 15 m height. In addition, the angle of the board inclination was different in both variants. The anchor position on the board I was changing with length increments of 2 m; and on the board II – in increments of 3 m. The angle changed from – 10˚ to 60˚ with increments of 10˚. The results are shown in Table. 2. Highlighted cells show the highest factor of rigidity margin.

Table. 2

Board №	h anchor, m	-10˚	0˚	10˚	20˚	30˚	40˚	50˚	60˚
I	2	1.47	1.48	1.49	1.49	1.49	1.48	1.45	1.43
	4	1.45	1.46	1.47	1.47	1.46	1.45	1.44	1.42
	6	1.44	1.45	1.45	1.44	1.44	1.42	1.41	1.39
	8	1.43	1.43	1.43	1.42	1.41	1.39	1.38	1.36
II	3	1.44	1.45	1.46	1.46	1.46	1.45	1.44	1.42
	6	1.43	1.44	1.44	1.44	1.44	1.43	1.42	1.4
	9	1.42	1.43	1.42	1.42	1.41	1.4	1.38	1.37
	12	1.41	1.41	1.41	1.4	1.39	1.38	1.37	1.31

According to specified ratios, there are several options of the angle inclination. The minimum distance of the anchor descentto a sliding triangle was determined. Thus, the most optimal inclination angles were found. These figures are marked by a dark color Table. 2. It was found out that the change of anchor inclination by 10˚ reduces its length by approximately 15-30% in the area from the slope surface to the sliding triangle.

Some conclusions can be drawn according the research results. Anchors should be placed in the lower section of slopes at an angle of 30˚; in the top section at the angle of 10˚; and in the central section at an angle of 20- 30˚. It can be proved by the highest factor of rigidity margin, and the shortest distance to asliding triangle.

Thus, an optimal position and the angle of ground anchors were found out in the process of similarmine workingsstudy. The position of security berms was also studied. According to the obtained data, it was proved that security berm does not affect the rigidity of the board in a homogeneous massif. It is caused by the need to ensure rigidity by increasing the width of security berm from minimum to optimum indices.