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STUDY OF THE QUARRY SIDE SCOPE AND ROCK MASS COEFFICIENT FOR MANAGEMENT DECISION MAKING

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ABSTRACT

The design and parameters of the non-working sides of the quarry must meet the requirements of stability and placement of the necessary platforms on them. A decrease in the angle of inclination of the side by 2-3° at the time of quarry closure leads to a significant increase in the volumes of overburden removed and the costs of field development. An excessive angle of inclination of the side compared to the angle of the stable slope can cause landslides and rock collapses. The selection of the optimal contours of the quarry is very important when mining mineral deposits, since the volume of industrial reserves of minerals and the volume of overburden in the quarry, which determine the productivity and life of the quarry, depend on them.

Keywords: quarry, side, side inclination angle, mineral, overburden rock, metal, ore quality, stripping ratio.

INTRODUCTION

The angle of repose of the sides of the final contours should be determined with the greatest possible accuracy, and the angle of repose of the sides of the prospective and intermediate contours should be determined approximately, since it is subsequently refined taking into account operating experience. The stable angle of repose of the sides is determined by the condition of the accepted stability margin of the given height of the ledge and the side, taking into account geological and other factors.

Most of the methods used for calculating the angle of repose of sides and benches are based on determining the shear and retaining forces acting along the most probable sliding surface. An important part of the calculation is determining the shape of the probable sliding surface of the slope. The stability factor of the pit sides is assumed to be in the range of 1.15-1.2 when the service life of the slope is more than 5 years. If there are no weakening and plastic layers at the base of the rock mass, then a convex side profile is recommended.

In the technological design standards for ferrous metallurgy quarries, it is recommended to determine the angles of inclination of the quarry sides by analogy with exploited deposits

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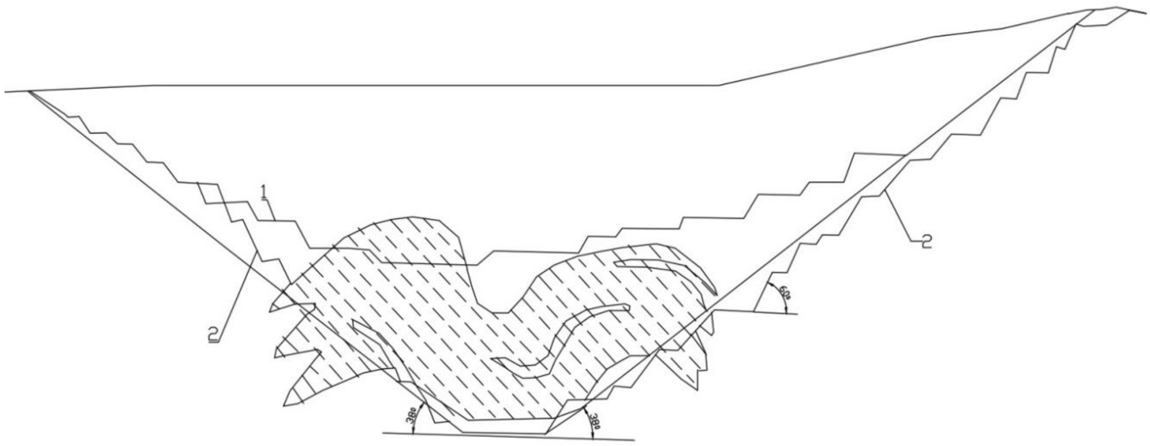
when drawing up technical specifications and feasibility studies of conditions, by calculation when developing feasibility studies and technical projects, by calculation during additional studies at the primary development site (at the stage of working drawings for deposits with difficult conditions), by calculation based on field research data (after opening the deposit). The rules of technical operation in open-pit mining of coal and shale deposits provide for the adjustment of the inclination angles of the sides and slopes of non-working benches by the surveying and geological service in accordance with the recommendations of design and research organizations.

Slopes of non-working ledges, which are structural elements of non-working sides (extinguished or preserved), must have long-term stability with a stability factor of more than 1.5-2 in clayey and fractured rocks and more than 1.85-2.2 in sandy and gravel rocks. When developing new deposits, the angle of stable slopes of benches and sides is often taken as approximate based on experience in similar conditions. In a quarry reconstruction project, the angles of inclination of the damped sides are taken to be more accurate , since they are based on research and experience of the enterprise in the first period of operation of the deposit. The main reason for collapses and landslides of sides is the presence of weakening zones and unfavorable structures in certain areas, which are identified during operation.

Constructive The angle of inclination of the stable side of the quarry should allow the placement of safety platforms and transport platforms on board. It depends on the type of transport, the width of the berms and the angle of repose of the ledges. With a simple route of internal capital trenches, it ranges from 35-37 to 41-42° and is usually determined by graphical construction. Examples of the design of pit sides made for various conditions are shown in Fig. 1.1.



RICE. 1.1. **DESIGN OF THE DESIGN DAMPING SIDES**: 1,2 - contours of the working and final sides, respectively

The width of the platforms and their number on the non-working side of the quarry depend on the method of opening, the type of transport and are regulated by the "Unified Safety Rules for Open-pit Mining". The width of the platforms for placing capital ramps and connecting berms is determined by the requirements of safety rules and depends on the size of the rolling stock, required clearances, placement of various structures, snow removal conditions (in the northern regions), etc.

The angle of inclination of the side, ensuring the placement of transport platforms in rocks, is, as a rule, less than the angle of inclination of the stable side. This circumstance causes an additional volume of overburden in the quarry contours.

At the first stage of design, when the issues of opening have not yet been resolved, the angle of inclination of the side, ensuring the placement of capital ramps, can be taken as indicative by analogy with existing or designed quarries. Then it must be clarified. To roughly establish the angle of inclination of the pit sides, you can use the data in Table. 1.1.

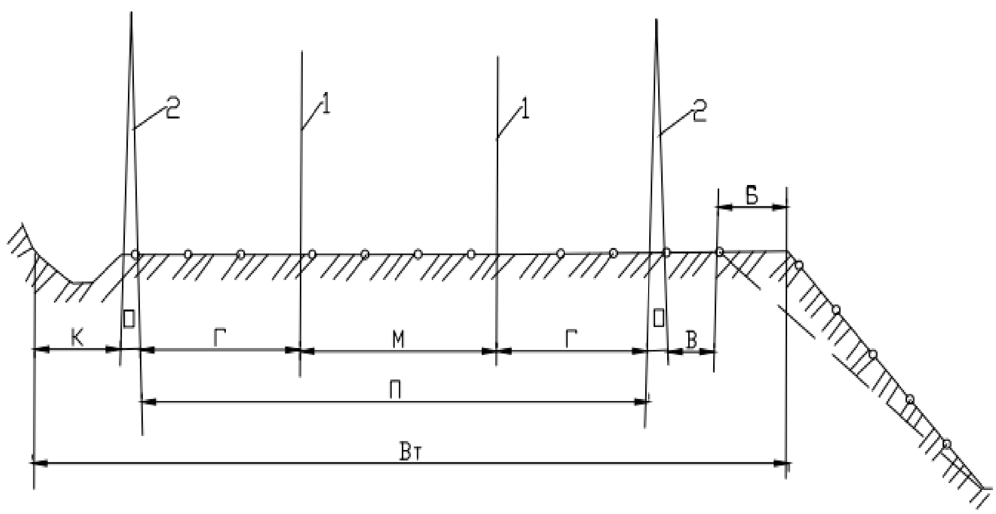
Table 1.1. Constructive angle of inclination of the quarry side

Ber width, m	Angle of slope of the ledge, degree	Angle of inclination of the quarry side, degrees, at the height of the ledge, m					
		10	15	20	30	**45**	60
10	50	38	33	36	40	-	-
	60	32	38	42	47	-	-
	70	36	44	49	55	-	-
15	50	23	28	32	36	40	-
	60	25	32	36	42	47	-
	70	28	36	41	49	55	-
20	50	19	24	28	33	37	40
	60	21	27	32	38	44	47
	70	23	30	36	44	51	55

Design and dimensions of transport berms

The width of transport berms in quarries is different for loose and rocky rocks. It also depends on the type of transport, the number of tracks and the size of the rolling stock. For electric locomotive transport, the berm **Вт** (Fig. 1.2.) includes a reserve safety berm **Б**, a roadbed П, a ditch К cut-off **А** and a strip for installing contact network supports **О.** The width of the reserve safety berm **Б** is assumed to be equal in rocks from 1 to 1, 5, in loose ones from 1.5 to 2 m, respectively, with a ledge height of 10 and 20 m.

The width of the ditch at the top is 1 and 1.65 m, respectively, in rocky and loose rocks. The contact supports occupy a strip 0.4 m wide. The distance from the contact support to the safety berm is **Б**=1 m, and the distance from the axis the path to the safety berm is 2.75 m and 2.5 m, respectively, in loose and rocky formations.



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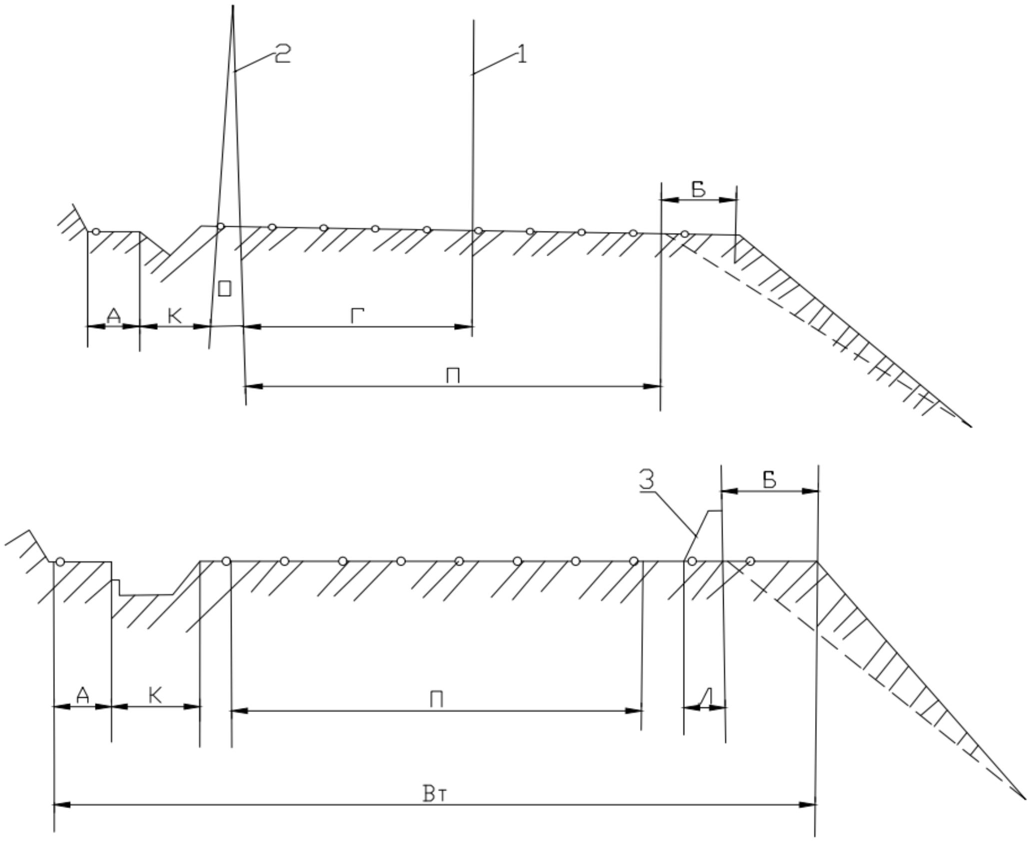

Rice. 1.2. Transport berm designs: a - double-track in loose rocks; b - single-track in rocks; c - for road transport with a protective shaft and a protective wall, respectively; 1 - railway axis paths; 2 - contact support; 3 - protective wall.

Table 1.2.

Distance between axes of stationary railway tracks, mm

Load capacity dump car, t	On double tracks highways	On multi-track highways between the axes of the second and third tracks
Up to 85	**4100**	**5000**
85—120	**4600**	**5040**
180 or more	**5000**	**5300**

The distance **M** between the axes of stationary tracks depends on the load-carrying capacity of dump cars and is taken from 4.1 to 5.3 m according to the table. 1.2.

When crossing a berm with a 6 kV power line, the distance from the power line support to the roadbed must be at least 6.1 m.

The width of transport berms ranges from 8-15 and 10-19 m, respectively, in rocky and loose rocks (Table 1.3.).

For road transport, the width of the transport area includes similar elements, a shoulder 1-2 m wide, the roadway **П** and lanes occupied by a protective rock embankment or safety wall.

The width of the roadway with two lane traffic is 12-16 m for 40-75 ton dump trucks, 17-20 m for 100-160 ton dump trucks (Table1.4).

In accordance with safety rules, quarry roads on the side of the slope must be fenced with a rock shaft.

Table **1.3.** Width of transport berms, m

Transport	Breeds	
	loose	rocky
Railway with electric locomotive traction:		
single track	**8.90+b**	**7.5+b**
double track	**14.75+b**	**13.60+b**
traveling	**15.95+b**	**14.80+b**
Railway with diesel traction:		
single track	**8.15+b**	**6.50+b**
double track	**12.25+b**	**10.60+b**
traveling	**13.45+b**	**11.80+b**
Automotive	**4.65 +a+b**	**4.5 +a+b**
Trolley carrier	**7.45 +a+b**	**7.30 +a+b**

Note, b - width of the split safety berm; a is the width of the roadway.

Table 1.4. Width of the roadway, m

Rolling stock	For two-lane traffic, freight density (gross), million **t/year**			In single lane traffic
	15	5-15	5	
Dump trucks with payload capacity 10-12 t and width up to 2.75 m	**-**	**8.5**	**8**	**4.5**
Dump trucks with payload capacity 27-30 t and width up to 3.5 m	**11**	**10.5**	**10.5**	**5.5**
Dump trucks with payload capacity 40-45 t and width up to 4 m	**12.5**	**12**	**11.5**	**6**
Dump trucks with payload capacity 65-75 t and width up to 5 m	**15.5**	**15**	**14.5**	**7**
Dump trucks with payload capacity 100-120 t and width up to 5.5 m	**17**	**16.5**	**16**	**8**
Dump trucks with payload capacity 160-180 t and width up to 6.5 m	**20**	**19.5**	**19**	**9**

Note. The width of the carriageway of a road with regular traffic of road trains (semi-trailers) increases by 1 m.

However, its height, which ensures the retention of a dump truck in the event of an accident, even for 27-ton vehicles exceeds 1.5-2 m and, therefore, its installation requires a strip 3-4 m wide. Therefore, when driving dump trucks with a carrying capacity of 40 tons or more, it is necessary to create reinforced concrete protective fence, which can be placed on the strip A the width is less than 1-1.5 m. With this design, the width of the highway ramps is 20-30 m.

In some cases, the width of exit ramps is increased by creating a reserve lane to ensure continuity of movement of dump trucks when repairing roads and clearing them of snow.

Stripping and rock mass ratios

The stripping ratio is the ratio of the volume or mass of overburden to the volume or mass of the mined mineral. In other words, the stripping ratio shows the amount of waste rock that must be removed and moved to dumps in order to extract a unit mass or volume of a

mineral. In practice, different dimensions of the stripping ratio are used.
The volumetric stripping ratio is the ratio of waste rock to the volume of minerals (m^3/m^3), and the mass stripping ratio is the ratio of the mass of waste rocks to the mass of minerals (t/t). In the coal industry, stripping ratio refers to the number cubic meters of rock moved during the extraction of 1 ton of coal, and is measured in m^3/t. This dimension is also used in other branches of the mining industry, but in copper ore quarries the volumetric stripping coefficient is more often used, and in iron ore and construction materials quarries - the mass stripping coefficient.
There are average, layer, contour and current stripping ratios.
Average industrial stripping ratio - this is the ratio of the total volume of overburden (m3) to the volume of minerals (m^3) in the contours of the quarry at a given development depth, i.e.

$$k_{cp} = V/Q,$$

Average operational stripping ratio$K_э$ - this is the ratio of the volume of overburden extracted in the contours of the quarry during the period of operation, i.e. without capital mining works, to the volume of minerals extracted in the same period in the same contours, i.e.

$$K_э = \frac{V-V_o}{Q-Q_o},$$

where is the total extracted volume of rocks in the contours of the quarry, m^3; V_o-volume of rocks removed at the expense of capital costs during the construction of the quarry, m^3; Q-total extractable volume of minerals within the quarry contours, m^3; Q_o- volume of minerals extracted at the expense of capital costs during the construction of the quarry, m^3.
Contour stripping ratio - this is the ratio of the volume of overburden removed by expanding the contours of the quarry to the mineral reserves extracted at the same time:

$$k_к = V_к/Q_к,$$

Current stripping ratio - this is the ratio of the volumes of waste rocks $V_т$ removed over a certain period of time to the actual extraction of minerals $Q_т$ over the same period:

$$k_т = V_т/Q_т,$$

The considered stripping coefficients are geometric indicators, as they are established by measuring the amount of overburden and minerals.
When designing and developing mineral deposits, they also use planned and boundary or maximum stripping ratios, which are economic indicators.
Based on the planned stripping ratio, the amount of repayment of stripping costs during the operation period is determined.
Based on the marginal stripping ratio, the comparative economic efficiency of open-pit mining is assessed and, in approximate calculations, the final and promising contours of the quarry are found, including the final depth of the quarry.
The rock mass coefficient is the ratio of the amount of rock mass removed to a unit of a useful component, for example, metal, extracted from the subsoil:

$$k_{г.м} = \frac{V_{г.м}}{Q_м} = (V_и + V_в)/Q_м,$$

where $V_{г.м}$, $V_и$, $V_в$ -volume of rock mass, mineral and overburden, respectively, m^3; $Q_м$ - amount of metal, t,

$$Q_м = V_и \gamma \alpha$$

where -c is the average density of the mineral, t/m^3; α- average content of a component in a

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mineral (for example, metal in ore), fraction of units.

Substituting the expanded value $Q_м$ into the expression $Q_м = V_и\gamma\alpha$, we get

$$k_{г.м} = (1 + k_в)/\gamma\alpha,$$

where $k_в$ is the stripping ratio, m^3/m^3.

The rock mass coefficient can be expressed in the same form as the stripping coefficient, i.e. as average, contour, boundary, etc. The rock mass coefficient reflects not only the influence of stripping operations, but also the quality of the mineral and is therefore more general than the stripping ratio, and more fully characterizes the effectiveness of a particular option for open-pit mining[8].

CONCLUSION

The following analyzes show that, during the development of mineral resources, the stripping ratio, widely used in determining the boundaries, productivity and mode of mining operations, is not effective enough, and sometimes even loses its meaning. The use of the stripping ratio leads to incorrect methods for optimizing this indicator and incorrect determination of the cost of extracting minerals, and this, in turn, makes the current methods for determining the main parameters of a quarry for making management decisions imperfect. Thus, in the conditions of deposit development, the stripping ratio, as the main indicator of the efficiency of a quarry, has a significant drawback - it expresses the ratio of overburden to the volume of minerals, but does not take into account its content. The relationship of overburden rocks to different metal contents in ore or to the amount of mineral value is illogical. Drawing a conclusion for making management decisions, we propose to use the stripping coefficient as the main indicators of the rock mass coefficient.

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