HOW THE COHESIVENESS OF BLASTED ROCK AFFECTS
THE PRODUCTIVITIES OF QUARRY EXCAVATORS

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Until recently, ledge rocks were loosened mainly by exploding a single row of borehole charges (up to 75 to 85%); this [1-3] causes intensive displacement and mixing and maximum breakup of the cohesion between the blocks of blasted rock. It has been considered that the influence of the properties of the spoil on the productivity of the excavators was adequately represented by the fragmentation index.

However, at the present time in open pits wide use is made of multi-row short-delay charges with various degrees of compression of the spoil. This improves fragmentation of the rock, but increases the density of the spoil and thus its cohesion. Little work has been done on the effects of these factors on output.

For this purpose we have developed a method and carried out research on the excavation of the spoil in the conditions of the Kal'makyr deposit, where the ledge rocks are mainly secondary quartzites, kaolinized syenite-diorites, and quartzitic granodiorite-porphyries, with hardneses of 8-14 on the Protod'yakonov scale.

The deposit was worked in benches of 10-15 m height. The rock was blasted by means of vertical boreholes containing charges 190-214 mm in diameter. Single and double rows of charges were used. The spoil was divided into three general categories according to its degree of cohesion.

The first category contained rock which was caved in the process of excavation and fell to the bottom of the face, being practically maximally loosened and minimally cohesive. The degree of loosening and free flow of this material (for rocks of similar compositions) depends mainly on the grain-size composition and shape of the fragments. The second category contained spoil which was not broken up by excavation.

The third category contained rock near the peripheries of the zones of the blasted block, where the solid rock, from the viewpoint of ease of excavation, can be considered as practically unbroken.

To establish how the degree of loosening of the ledge rock by blasting influences the productivities of the excavators, we recorded the duration of scooping in relation to the coefficient of loosening and the grain-size composition of the various categories of spoil.

As the criterion of fragmentation of the spoil, we took the fragmentation of the loaded rock, with the grain-size composition being measured by means of photoplans of the side surfaces of the heaps in the dump trucks.

In processing the photoplans, the rock was divided into four fractions by fragmentation. The index of fragmentation, the diameter of the average fragment diameter $d_{av}$, was calculated from the formula

$$d_{av} = \frac{d_1 \gamma_1 + d_2 \gamma_2 + d_3 \gamma_3 + d_4 \gamma_4}{100} \text{ mm}, \quad (1)$$

where $d_1$, $d_2$, $d_3$, and $d_4$ are the mean diameters of the fractions in millimeters, and $\gamma_1$, $\gamma_2$, $\gamma_3$, and $\gamma_4$ are the percentage contents of the corresponding fractions in the mixture.

Test blocks, most characteristic for the deposit, were chosen in ore zones of the quarry with approximately identical mining-technological indices. This enabled us to use the weights of rock in the trucks in the calculations.
and to eliminate nonproportional variations in the fragmentation index due to different degrees of crushing of the spoil.

The coefficient of loosening of the rock by blasting, \( K_{1,b} \), was found from the relation

\[
K_{1,b} = \frac{V_\gamma}{G}
\]  

(2)

where \( V \) is the volume of rock in the blasted state worked in the process of loading the trucks (measured by tachymetric photography) in cubic meters, \( \gamma \) is the bulk density of the solid rock (before blasting) in tons per cubic meter, and \( G \) is the weight of rock in the trucks in tons.

The coefficient of loosening of the rock in the excavator bucket, \( K_{1,e} \), was calculated from the formula:

\[
K_{1,e} = \frac{nq\gamma K_{n}}{G}
\]  

(3)

where \( n \) is the number of scoopings performed in loading the trucks, \( K_n \) is the average coefficient of filling of the bucket over \( n \) scooping, and \( q \) is the bucket capacity in cubic meters.

The specific duration of scooping, \( t_{s,s} \), for the corresponding type of rock, was calculated from the formula:

\[
t_{s,s} = \frac{K_{1,e} t_m}{g K_m} \text{ sec/m}^3,
\]  

(4)

*The denominator of the fraction labeling the axis of abscissas is illegible in the Russian original — Publisher.