Comparative Analysis Rock Mass after Explosions in the Quarry Liqhobong

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Abstract. The article provides a systematic analysis of the research results of rock mass granularity, including theoretical studies and generalizations of experimental studies, as well as methods of computer technology. The problem of determining the main cause of a large number of oversize at the Liqhobong quarry was solved, the methods used were analyzed and compared with each other, in accordance with factors such as the availability of the method, the difficulty of implementation, and the time factor. Analysis of digital images of explosions were obtained with a digital camera and processed in the software Split Desktop 4.0. In addition, rock fragmentation data were collected through the collection of data from eight drilling and explosive operations. Based on the results of this work, it was revealed that the oversize yield for explosions at the lower levels of the southern part of the quarry was higher than for the explosions that were made at the upper levels of the north of the quarry. Therefore, we can conclude that it is necessary to apply different methods of blasting in the south and in the north of the quarry.

1. Introduction
One of the main indicators that determine the economic efficiency of the enterprise is the quality of rock crushing by explosions. The evaluation of the efficiency of explosive crushing of a rock is determined mainly by two parameters: the output of the oversize load and the degree of crushing of rocks (figure 1). Currently, there is a large number of both domestic and foreign models that make it possible to predict both of these parameters [1, 2].

**Figure 1.** (a) The crusher Blocked by oversized pieces.  
**Figure 1.** (b) Work on unlocking the crusher.
Heterogeneity of rock pieces and sizes is a serious drawback, so the granulometric composition of the exploded rock is of great importance - the quantitative ratio of the content of pieces (particles) of different sizes in the exploded mass. Based on this, the work was carried out in such a way that as a result of the primary explosion, the rock mass was evenly divided into movable pieces of rock, and the output of oversized pieces was reduced to a minimum value, that is, the degree of fragmentation of rocks corresponded to the parameters of handling and crushing machines. To determine the granulometric composition of the rock mass, several methods were considered [3]. The quality of the explosion was determined by the results of surveying the collapses of the rock mass after the explosion. The impact of oversize yield on parameters such as the bucket capacity of the excavator, width, collapse, etc. was considered and analyzed. Analysis of digital images of explosions were obtained with a digital camera and processed in the software Split Desktop 4.0. In addition, rock fragmentation data were collected through the collection of data from eight drilling and explosive operations [4-6]. Additional data on the analysis and forecasting of granularity were collected from the data of the archives of the enterprise and were analyzed in accordance with the presented data. In addition, additional factors that may have an impact on the quality of the rock explosion in the mining area were considered, evaluated and included in the overall analysis of the study problem, as indicated above.

The methods used were analyzed and compared with each other, in accordance with the following factors [7]:

- the Practicability of the method – the method should be practical in accordance with the conditions of the studied field;
- the Accuracy of the Method – when choosing a method, its accuracy is estimated, it should determine the results with a given accuracy;
- the Complexity of the method – the method should not be very time-consuming;
- the execution Time of works by this method – the method should not take very long;
- the Safety of the method – the implementation of the method should be in the aisles of the safety rules of the enterprise.

2. Relevance

Until now, there is no scientifically grounded approach to the operational determination of the parameters of the blasted mass for a given granulometric composition, taking into account the physical and mechanical properties of the mined section of the rock mass. Therefore, the search for the most effective methods for assessing and taking into account the features of the physical and mechanical characteristics of destroyed rocks is an urgent scientific and practical task. The work of V. Adushkin, V. Borovikov, S. Viktorov, I. Zharikov, R. Kryukova, G. Kryukova, B. Kutuzov, N. Melnikov is devoted to the problem of rock destruction by explosion.

3. Statement of the problem

The main goal of this article is to find the most effective method for determining the quality of drilling and analyzing the particle size distribution by comparing various methods for analyzing the rock mass for various indicators and criteria, process the data and get a conclusion confirming the data presented.

The subject of research is the rock mass, the Liqhobong quarry, and in particular the reason for the appearance of a large number of oversize after the explosions.

4. Theoretical part

Methods of surveying the collapse of the broken rock mass (laser Scanning method). The method is the remote collection of spatial information using specialized devices – ground laser scanners [8]. The principle of operation of the laser scanner is similar to the principle of non-reflective electronic tacheometer and is to measure the time of passage of the laser beam from the emitter to the reflecting surface and back to the receiver. By dividing this time by the speed of the laser beam, the distance to
the object is determined. Measurements occur at a speed of several thousand points per second. The angles in this case are not measured, but are set by turning the mirror, simultaneously registering the storage device [9, 10]. The point clouds obtained from each scan position are combined into a single coordinate system in the software environment, as a result of which a single high-detailed point three-dimensional model of the pit rock mass is formed. When performing this work, the collapse of the rock mass was removed (figure 2) laser scanner Renishaw Quarryman Pro Laser scanner and GPS receiver Trimble R10 (figure 3) [11].

![Figure 2. General geometric figure/shape of the broken rock mass measured by the laser scanner in 3d.](image1)

![Figure 3. Renishaw Quarryman Pro Laser scanner with GPS Trimble R10 Receiver.](image2)

Advantages:
- remote data collection eliminates the access of personnel into the hazardous area, i.e. about the broken strata of rocks, which may not be stable;
- high-precision and detail of the obtained data;
- high performance in the collection of data;
- easy creation of detailed three-dimensional models (figure 2).

Disadvantages:
- labor-intensive work (the necessary movement of heavy equipment on the field and back);
- the Impact of weather conditions (in bad weather conditions, it is difficult to perform).

Using GPS-Receiver. In this method, the artist walks and captures the point of collapse. After a sufficient number of points are captured, the results are processed to determine the parameters of the collapse, such as the volume of the rock mass, the height of the broken rock mass, the coefficient of loosening of rocks after the explosion, etc. [12, 13].

Advantage:
- you can capture as many points as the contractor needs; • the Work is performed under the control of the contractor.

Disadvantages:
- very time-consuming work as it is necessary to walk around the collapse, takes a very long time, especially in large ruins;
- very dangerous as from the capturing of points produced on unstable rock mass;
- impractical, since the quarries after the explosion usually immediately begin loading and transportation operations.

In mining operations, there are direct and indirect methods of determining the output of the oversize fraction of the breed:

a) Piece record (measurement) oversized to be secondary blasting. The method consists in full-scale measurement of oversize in the field. But, direct measurement of the total area of some piece on the surface of the collapse is almost impossible.

Disadvantages:
- impracticality - it is difficult and sometimes impossible to make a piece account of all oversized pieces at the collapse;
• low accuracy - due to the fact that oversized pieces are considered piece by piece, the accuracy is very low, as it is not easy to count all the pieces;
• laboriousness - for the same reason piece account of all oversized pieces, the method becomes very laborious;
• danger - very dangerous for a long time at the collapse of the broken mountain mass.

b) Planimetric Method of Measurement – the output of the oversize is defined as the ratio of the total area of the oversized pieces in the plan to the total area on which the measurements are carried out [14]. It is advisable instead of time-consuming measurements on the collapse of the breed to photograph it, and then do the analysis of photos taken at a certain scale. This method is called photopolarimetric.

Advantages:
• the work takes quite little time with this method, since it is not a labor-intensive method because instead of labor-intensive measurements on the collapse of the breed to photograph it;
• security.

Disadvantages:
• low accuracy due to the fact that the account of non-intake pieces is made with the naked eye and there is a possibility of human error, as well as possible errors in the scale of the photo.

c) Quantitative Method – the number of oversized pieces are located on the analyzed area S is calculated. In this case, the number of oversized pieces per 1 m³ of rock mass is calculated as in equation (1).

\[ N = \left( \frac{n}{S} \right)^{3/2} \]  

And the output of oversized, as in equation (2), where \( V_{med} \) is the average volume of the blasted rock mass, m³.

\[ V_H = NV_{med} \]  

Advantages:
• due to the fact that the output of the oversize is considered to be semi-empirical formula, it is not necessary to analyze the entire collapse of the rock mass, so it takes quite a little time [15-18].

Disadvantages:
• the method is time-consuming, because it is required to analyze a certain area of rock mass by pieces taking into account the oversized pieces of rock mass;
• the danger is increased, as the staff must be located in the quarry area where other more dangerous operations are performed;
• impracticality - usually in the quarry, right after the explosion they begin loading and transportation operations, so it is not easy to have time to do the work before the start of these operations with this method;
• low accuracy - due to the fact that the output of oversize is considered to be semi-empirical formula, the accuracy of the results is much humiliated.

d) Linear Method – the collapse of the exploded rock through 8...10 m stretched tape and then they measure the length of large pieces that fall on them. The output of gauge is defined as the ratio of the total length large oversized pieces \( \sum l_{hk} \) total length of the line \( \sum L \).

Advantages:
• due to the fact that the output of the oversize is considered to be semi-empirical formula, it is not necessary to analyze the entire collapse of the rock mass, so it takes quite a little time.

Disadvantages:
• low accuracy - the accuracy is reduced because only the size of large oversized pieces and the output of oversized pieces of rocks is measured;
• impractical - due to the fact that it is necessary to stand at the collapse and produce a piece account of the irregularities within the tape.

e) Sieve Analysis – rock mass is sieved through sieves with decreasing cell sizes, as a result, its particle size distribution is established. Distinguish between the primary blasting in which the explosive is produced in order destruction of the mountain range, and the secondary – crushing of oversized blocks [19]. Therefore, in production conditions, the output of oversize is also estimated by the consumption of detonators and EXPLOSIVES for secondary crushing (indirect method).

Disadvantages:
• impracticality - the method is not practical under quarry conditions, since it is almost impossible to use a sieve on the collapse of the rock, in a career, the use of this method can take a very long time, interfere with and greatly slow down other production processes. and so very time-consuming way;
• the danger is greatly increased as personnel will always need to be in hazardous areas of rock mass collapse.

5. Proposals and implementation results
All of the above methods are very time-consuming, not practical and not accurate in case of large explosions in the quarry, so the method of analysis of digital photographs using computer technology was used in this work. This method is less time-consuming as it is advisable instead of time-consuming measurements on the collapse of the breed to photograph it, and then do the analysis of photos taken at a certain scale. This method is similar to the photoplanimetric method but differs from it in that the analysis of the photo is done using the software "Split Desktop" Version 4.0, which was developed by "Split Engineering".

Advantage:
• work takes a little time and not time consuming in this method, instead of time-consuming measurements at the breakdown of rocks to photograph him;
• safety is increased by using this method, as the staff is not necessary for a long time at the collapse;
• practical in a quarry - you only need to take photos and make a record of oversized pieces;
• unlike photopolarimetric method when using this method of analysis the granulometric composition of the rock mass, given the oversized pieces is done in an automated manner, therefore, the scaling error is completely eliminated.

Table 1. Comparison of methods of efficiency of methods of surveying of disorder of mountain weight at first phase research.

| Criterion  | Method evaluation % |
|------------|---------------------|
|            | Laser scan | GPS Receiver |
| Practicality |       100   |      50     |
| Lead time   |       95    |      20     |
| Security    |       100   |      5      |
| Accuracy    |       100   |     100     |
| Labor intensity | 95     | 10        |
Table 2. Comparison of the efficiency of methods for determining the granularity of the exploded rock mass at phase 2 of the study.

| Criterion          | Piece accounting | Planimetric | Quantitative | Linear | Sieve | Auto Photo Planner |
|--------------------|------------------|-------------|--------------|--------|-------|-------------------|
| Practicality       | 0                | 95          | 20           | 10     | 0     | 95                |
| Lead time          | 10               | 20          | 30           | 20     | 0     | 90                |
| Security           | 10               | 100         | 15           | 5      | 0     | 100               |
| Accuracy           | 10               | 60          | 10           | 10     | 100   | 98                |
| Labor intensity    | 10               | 80          | 5            | 40     | 10    | 80                |

The method of laser scanning during the 1st phase of the study was more effective in all criteria, while in the 2nd phase of the study a more effective method was automated photoperiodicity. Thus, the study will be conducted in two stages. The first stage is to determine the drilling and blasting of six explosions by calculating the parameters of the collapse of the rock mass on the results of surveying the collapse of the rock mass after the explosion [20]. To perform this part, the laser scanning method was chosen because it was more practical, fast, safe for quarry conditions "Liqhobong". The second stage will be to determine the yield of oversized pieces by analyzing the particle size composition of the exploded rock mass at the collapse. For this stage, we chose the method of analysis of digital photographs of the broken rock mass on the computer software "Split Desktop" version 4.

6. Conclusions

Thus, to determine the output of oversized pieces by analyzing the particle size distribution of the blasted rock mass on the collapse, a method was chosen for analyzing digital photographs of broken rock mass using a computer software called Split Desktop version 4. This method turned out to be more practical, safer, faster and more accurate than other methods. Based on the results of this work, it was revealed that the oversize yield for explosions at the lower levels of the southern part of the quarry (10% for the O2575C1R18-South explosion) was higher than for the explosions that were made at the upper levels of the north of the quarry. Therefore, we can conclude that it is necessary to apply different methods of blasting in the south and in the north of the quarry. In the north of the quarry, its okay to continue applying existing methods of blasting, and in the south of the quarry, there is a need to make changes to the method of blasting.

7. References

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