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# Strength Properties Analysis of Exploded Mine Rock Pieces

Valentin Alexandrovich Isheiskii and Matvey Matveevich Yakubovskiy
Saint-Petersburg Mining University, 21 Line V.O. 2, 199106 St. Petersburg, Russia

**Abstract:** This analysis is a part of the research devoted to the affect of energetic characteristics of explosives to strength properties of exploded mine rock pieces. We show here the results of a model experiment how the energy of blast-hole can influence strength properties of mine rock pieces with respect to ruptured zones.

**Key words:** Explosion, blast, blast-hole, ruptured zones, model

## INTRODUCTION

The quality of explosion preparation of mine rocks to benefication significantly influences both conservation of mineral raw materials in particular and economical values of the plant work in general. When processing roche to make breakstone, we have significant yield of rock fines whose volumes depend on strength properties of mine rocks (Isheysky *et al*., 2014; Paramonov and Isheysky, 2014). To make research of the influence of parameters used in drilling and blasting work to strength properties of pieces after exploding mine rocks seems to be a scientific task of current concern and a practical task for any mining enterprise.

## MATERIALS AND METHODS

Our aim in this research is to estimate strength properties of exploded mine rock pieces when we have blasts with different characteristics. To study the strength reduction of a mine rock piece in different zones of destruction volume, we carried out a set of experiments by means of physical models made of materials equivalent to roche observing physical and geometrical similarities. In our laboratories, we made model blocks meeting the requirements of similarity when modelling the natural environment-deposits of granites (Isheysky, 2014).

To prove numeric calculations model experiments were carried out on cylindrical blocks. When realizing a model of zone blasting a removable frame of hollow thin-wall cylindrical forms of different diameter was created. The total amount of cylinders is 6 pieces. Cylinder radius ranges from 10-100 relative charge radii ($\bar{r}$). The height of all cylinders is 80 relative radii. You can see constructional parameters and model view illustration in Fig. 1.

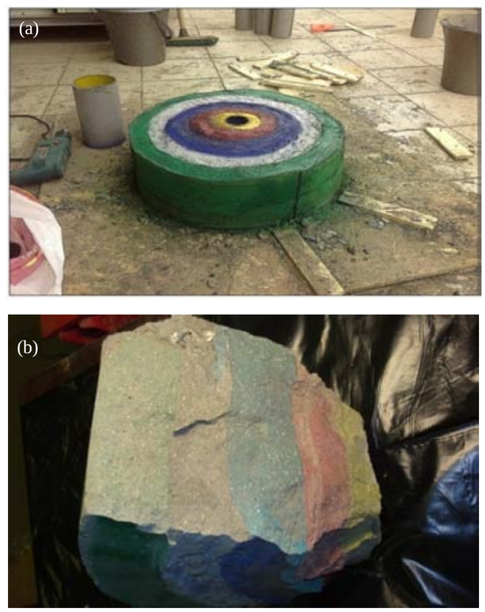


Fig. 1: a) External model view and b) Internal model structure

The main condition to choose charges and to prepare them for the experiment was the same value of linear parameters. We used fine-crystalline tetranitropentaerytrite as an explosive substance. The energetic characteristics of the explosive substance were changed by means of adding sodium chloride to a charge column from 0-20% with a change of 10% (corresponding charge No. 1-0% NaCl, No. 2-10% and No. 3-20%).

We drilled bores in model blocks with the diameter of 5 mm and the depth of 150 mm, after that we charged them. The quantity of fine-crystalline tetranitropentaerytrite used for charging was carefully weighed then we defined the charge length, actual charge density and charge linear mass.

**Corresponding Author:** Valentin Alexandrovich Isheiskii, Saint-Petersburg Mining University, 21 Line V.O. 2, 199106 St. Petersburg, Russia

To initiate a model charge in the opening of the channel we introduced an initiator of lead azide. The model was put into an insulated vessel to rule out material loss after the explosion. After main stages of preparation the model was located in an explosion chamber.

## RESULTS AND DISCUSSION

When carrying out our model experiments, we estimated the mediumsize piece from different destruction zones and strength limits for uniaxial compression before and after the explosion affect.

The volume of exploded mass from different destruction zones (Fig. 2) was divided according to colours, after that we definedthe coarseness of grading and the medium piece size from each destruction zone separately by means of the program complex WipFrag (Maerz *et al*., 1996; Maerz, 1996).

To define strength characteristics of exploded mass pieces we wanted to test samples from different destruction zones for point strength by means of an apparatus of point load TS706 (Paramonov and Isheysky, 2014) produced in accordance with the standard ASTM D5731.

Knowing the value of specific consumption for different series of explosions we can find out the value of specific energy consumption:

$$E = qQ,\ \text{MJ/м}^3 \qquad (1)$$

Where:

Q = Specific power (MJ/kg)
q = Specific consumption BB (kg/$м^3$)

Based on existing results, we received power dependence which allows us to predict the strength limit for the compression of an average size piece supplied to a grinder depending on the specific power/weight ratio:

$$\left|\sigma_{сж}\right|_{ср} = 426,25\ E^{-0.7} \qquad (2)$$

where, E-specific energy consumption BB, MJ/$м^3$ strength limit for uniaxial compression of a medium size piece (MPa). If we consider the results given in reports (Sasaoka *et al*., 2015) and we take into account that the strength of a medium piece of exploded mine rock mass is a function of the distance from the explosion source then we can calculate the coefficient of strength reduction for granites in question in relation to unbroken material in each zone from the change of specific energy consumption. Thus, the strength of a medium size piece after the explosion with respect to destruction zones can be shown as follows:

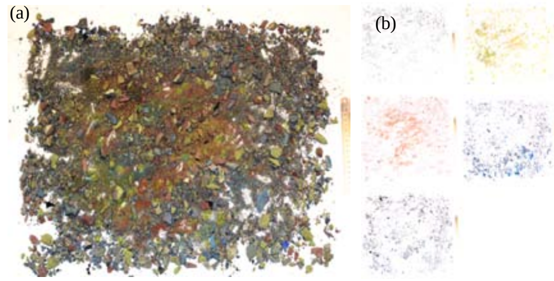


Fig. 2: The coarseness of grading of exploded rock mass: a) General content and b) Content divided according to colour spectrum

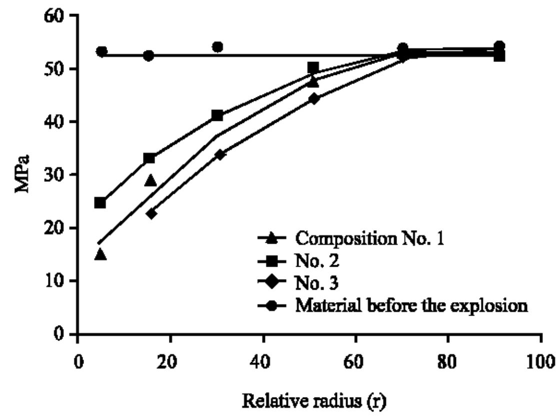


Fig. 3: Dependence of mine rock strength limits for uniaxial compression on relative radius

Table 1: Strength limits for uniaxial compression

| Mixture content tetranitropentaerytrite/ NaCl | Zone radius from the charge center ($\bar{r}$) 0-10 | 11-20 | 21-40 | 41-60 | 61-80 |
|---|---|---|---|---|---|
| 100/0 | 24.0 | 39.6 | 52.2 | 58.05 | 59.04 |
| 90/10 | 32.4 | 45.0 | 54.2 | 57.50 | 58.50 |
| 80/20 | 49.2 | 52.8 | 55.2 | 58.50 | 59.20 |
| Source material | 59.2 | 58.5 | 585.0 | 59.20 | 60.20 |

$$\left|\sigma_{сж}\right|_{ср} = \sum_{i=1}^{n} \left|\sigma_{сж}\right|_{м} k_i \cdot \frac{V_i}{V_{общ}} \qquad (3)$$

Where:

$V_i$ = Volume of destruction zone ($м^3$)
$V_{общ}$ = Volume for all zones ($м^3$)
$|\sigma_{сж}|$ = Strength limit of mine rocks for uniaxial compression before the explosion (MPa)
$k_i$ = Coefficient of strength reduction in a zone
n = No. of destruction zones

Strength limits for uniaxial compression of exploded mine rock pieces from different zones according to the distance from the charge after some model experiments are given in Table 1 and Fig. 3.

The analysis of experiment results shows that the strength of a piece of exploded mine rock mass is a function of the distance from the explosion source. During the explosive rupture by means of charges with high energetic characteristics we had a formation of mine rock pieces whose strength was lower than the strength of pieces when we used charges of lower energetic. For example, at relative radii between 20 and 40 $\bar{r}$ the difference in strength of such pieces was 15-20% from each other.

Measured values of strength reduction shown in Fig. 3 can be divided into 3 sections. Maximum reduction of strength occurs in the first section (interval from 0-30 $\bar{r}$). In the section from 31-50 $\bar{r}$, the change of strength is not obvious enough. In the third section from 51-80 $\bar{r}$, there wasn't any visible strength reduction. In this zone explosive work doesn't affect the change of piece strength in debris significantly.

## CONCLUSION

So, it is determined that the maximum reduction of mine rock strength is achieved in the section not exceeding 30 relative radii from the charge axis when we exploded continuous charge.

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