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CONTROLLED ROCK BLAST DESIGN ON THE HIGHWAY VRGORAC - PLOČE

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ABSTRACT
During the last decade - effective blast monitoring tools, effective blast design tools, geophysical exploration of rock masses, rock mass mapping and modelling system and fragmentation measurement system - have been developed and can now be applied to the problem of both estimating and achieving more controlled fragmentation. In the practical blasting, pre-blast assessment of rock mass, choice of appropriate geometry and diameter of boreholes, explosive parameters and blasting control are the most important parameters that influence blasting results. In blasting there is always the question of how well the blast has performed relative to the results required by the quarry, road building or mine operator. The assessment of blasting results generally considers such factors as: fragmentation and the percentage of oversize, muck pile profile, backbreak and back throw, flyrock and vibration and airblast. Rock excavation by blasting for the highway is held in complex environment. Such conditions force restrictive criteria which than protect environment from seismic influence and mechanical damage. Drilling and blasting plans on highways should be designed in the manner that professional personnel could carry out procedures in the safe manner.
Keywords: Rock Parameters, Explosives, Blasting, Fragmentation model, Highway

1. INTRODUCTION
Characteristics of blasted rock such as fragment size; volume and mass are fundamental variables effecting the economics of a mining operation and are in effect the basis for evaluating the quality of a blast [1]. The properties of fragmentation, such as size and shape, are very important information for the optimization of production. Optimal blasting is based on the results of test blasts; calculations with computer blasting simulations, and experimentally defined rock properties. Simple methods based on the geometry of discontinuity and statistical analysis of rock fractures may also serve to this purpose.

2. ENGINEERING GEOLOGICAL INVESTIGATION
Anisotropy or quaziisotropy of rock masses is defined with the existing discontinuities and their densities. Structural and geological observations enable, the tectonic phases, which has caused rock deformation, to be defined. Based on structural geological definitions, following sets of discontinuities in rock masses could be obtained:
- Bedding and interbedding cleavage;
- Axial plane cleavage;
- Fractures normal to local or regional structural axis b;
- Reverse faults with subvertical a- lineation;
- Diagonal faults with subhorizontal a-lineation;
- 'Pinnate' tensional fault fractures;
- Open fractures normal to tension direction;

3. DRILLING AND BLASTING OPERATIONS

Technological process involves following operations: humus cut, drilling of the blastholes and blasting, loading and transport of the blasted material and separation and blasting of the oversize material. It is necessary to survey geometry of boreholes, blastholes angles and depth of drilling to correspond with project solutions. It is necessary to record drilling and blasting plans as well as drilling logs. Drilling logs should note any changes noticed while drilling, like caverns, fissures, changes in soil properties and other. All this changes should be accepted while loading blastholes.

Blastholes should be cleared with compressed air and than checked for proper depth [2]. Prepared explosive charges along with the detonators are loaded in the blastholes and pushed into place with the wooden pole. In case of separated charges, stemming in between is usually sand or clay. Loaded blastholes are filled to the top with sand or clay.

It is known that inclination of the blastholes lower the influence of the seismic effects because significant part of the explosive is used on crushing and fragmentation and less on seismic disturbance. It is also not advisable to use detonating cord where highway route is in vicinity of historical or residential area.

In such a places it is advisable to use Nonel system or electric initiating system with the respect of allowable amount of the explosive charge per firing stage.

Mass blasting for excavation of the highway route should be performed in accordance with the Mining law.

Every mass blasting should have "blasting elaborate" with content as follows:

-micro location of the minefield

-minefield data (length, lift height, mass calculation, specific explosive consumption, sum of drill lengths, used explosive and other)

-borehole data (diameter, angle, borehole spacing, number of boreholes, burden,)

-explosive charge data (type, quantity, packaging,)

-initiating system data with retardation

-schematics of the delay patterns and connections

-schematics of the borehole cross-section with stemming design

-organization of the workplace and protective measures

Concerning different distances from the structures along the highway route, different technology and parameters are used along the route. Stated situation highlights necessity for precautions regarding all unwanted and harmful influence of the detonation, like: seismic effects, air shock, and excessive flyrock [3].

Figure 1. depicts fragmentation of the blasted material.

Figure 1. Fragmentation of the blasted material

Calculations of the blasting parameters Burden for terrains of similar characteristics is calculated and equals 2.5 m.
Borehole depth – L (m):

$$L = \left(\frac{H}{\sin\alpha} \right) + L_{pod.} \qquad \text{... (1)}$$

H – lift height,
α – borehole angle
$L_{pod.}$ – subdrill = (10 to 12 x $Ø_{borehole}$)/1000 (m)

Length of the principal charge – L_g = 2 (m)

Stemming length – $L_č$ = B (m)
B – burden

Length of the secondary charge – L_s (m):

$$L_s = L - L_g - L_č \qquad \text{... (2)}$$

Explosive quantity for the principal charge – Q_g (kg):

$$Q_g = L_g \cdot \left(\frac{\phi_b}{2} \right)^2 \cdot \pi \cdot \rho_g \qquad \text{... (3)}$$

ϕ_b – borehole diameter,
ρ_g – density of the principal charge

Explosive quantity for the secondary charge – Q_s (kg):

$$Q_s = L_s \cdot \left(\frac{\phi_b}{2} \right)^2 \cdot \pi \cdot \rho_s \qquad \text{... (4)}$$

ϕ_s – borehole diameter,
ρ_g – density of the secondary charge

Explosive charge sum – Q (kg):

$$Q = Q_g + Q_s \qquad \text{... (5)}$$

Displaced volume per borehole – V (m^3):

$$V = a \cdot B \cdot H \qquad \text{... (6)}$$

Lately, empiric methods have improved and prediction of the resulting fragmentation which will result from: designated geology structure, rock type, type of used explosive and borehole pattern ("SB" Software program). Empiric prediction of the wanted fragmentation is most commonly implemented using Kuz-Ram model. That is implementation of the Rosin-Rammler theory that offers reasonable description of the fragmentation and grade of the blasted material, which was initially recommended by V.M. Kuznetsov. Later works of other authors, including Claude Cunningham, served for improvement of the efficiency such a presentation. Thrust force of the explosive refers to relative thrust force of explosive **E**, which is stated by manufacturer and it influence middle fragment grade (x). Better understanding of the problem and quantifying of geological variations can optimize design procedure of blasting. It involves quality determination of the rock factor **A** which depend on the characteristic of the rock mass.

4. CONCLUSION

Drilling and blasting plans on highways should be designed in the manner that professional personnel could carry out procedures in the safe manner [4]. Calculated blasting parameters are not optimal, they should be recalculated with the progress of works and with change of the conditions in rock mass. A simulation of the calculations includes variations of burden, borehole spacing, construction of the boreholes, activation system. Used explosive charges: emulsive explosive is used for principal charges, and ANFO explosive for secondary charge.

Only professional personnel should work on all work positions, all machines should be certificated and operate properly. Personnel should wear protective clothing and equipment.

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