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Drilling and Blasting Influence on the Process of Contaminated Silt Formation

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Abstract: Influence of blasting and drilling charge types on contaminated silt formation at various distance from the charge have been considered in the study. Dependence of dust-gas cloud intensity of silt formation and its concentration at various blast areas for quarries of building materials have been presented as well.

Key words: Blast, silt, dust-gas cloud, high level contaminated zone, Russia

INTRODUCTION

A number of blasting in quarries cause significant damage to the atmosphere, hydrosphere, lithosphere of the Earth. While developing an open quarry the source of dust-gas particles turns up process operation of mining connected with drilling, mass blasting, loading and hauling operations. The share of blasting and excavation of the rock passing to the atmosphere quarries amounts about 70% of the total dust particles (Zykov, 1980).

Investigation established (Beresnevich, 2001) that drilling-and-blasting operations are the most harmful due to a lot of dust from blasting. So while drilling total amount of dust in atmosphere is 50-60% while blasting is 30-40% and the rest of mining operation such as loading, regrinding and etc. amounts only 10% of dust.

The contaminated level of a quarry and its area is defined with dust cloud features and its speed of dust particles settling out at the set speed of dust cloud transfer.

MATERIALS AND METHODS

Using the example of enterprise that is specialized in granites and granito-gneisses mining (Paramonov *et al*., 2014) the special experiments has been carried out with the purpose to investigate a level of environment pollution from blasting.

Volumes of particles distribution by the size and falling down of dust fractions have been determined by the technique providing tool measurements of dust fractions concentration at the earth's surface at various distances from the place of blast. Measurements have been carried out applying the following methods. The tablets for dust reception were installed in front of experimental mass blast in the direction of anticipated wind deflection of dust and gas cloud within the industrial zone of a quarry.

The tablet represents a rectangular sheet of pressboard with welts of 0.5 m^2 and with the sheet of Whatman paper pinned down. In order to avoid a dust drift from the surface of soil in the site, the tablet fastened on a wooden rack about a meter high. The first tablets were installed on border of a dangerous zone on scattering of splinters that made 300 m and then tablets were installed in the direction from the blown-up block with a step of 100 m as shown in Fig. 1.

The distance of 300 m is required because the dust made by the shock air wave and formed by the products detonation along a front surface of bench at its shift could penetrate on the surface of tablets at closer arrangement of tablets.

Accumulation of dust on the tablet was carried out during the whole time of wind deflection and cloud dispersion over area where tablets were installed and the time was not <30 min.

The dust collected from each tablet was underwent to the screen assay with fractions distribution from 1 micron to 400 microns, tests sifting of the dust investigated through sit set the stirring-up device that is the vibration mechanical gradation analyzer is used to simplify the experiment.

The lower limit of dust particles determination is limited within the capability of the sieve analysis method. Due to the limited application of the sieve method for a fraction <40 microns the microscopic analysis at the measuring scale microscope which is designed to measure the distance between the individual parts for example between strokes and object points as well as for measuring small linear objects in this case, dust fractions

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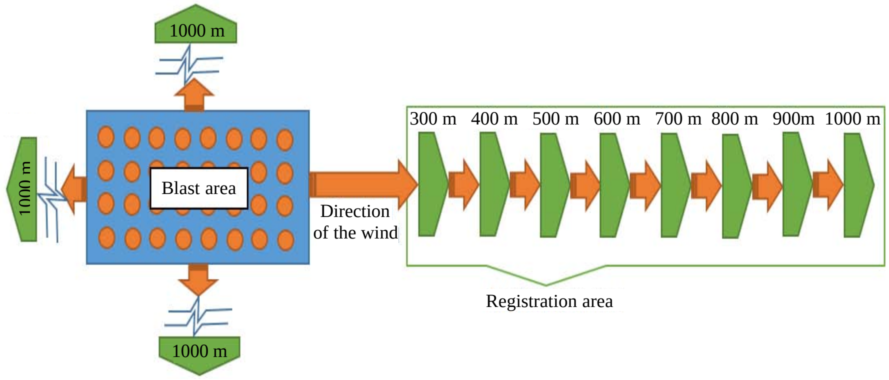

Fig. 1: Scheme of tablets arrangement

haven carried out particle dust structure was visible in the lens and was calculated and divided into fractions of 0-40 microns and then weighed. Thus, each measurement point corresponds to their distribution of dust particles according to fractions.

RESULTS AND DISCUSSION

The particle size distribution for the "Ostrovsky" quarry of column charge standard blast with drill cuttings of the block No. 1 are shown in Fig. 2 and Table 1.

The particle size distribution for the "Kamennogorsk" quarry, JSC "Kamennogorsk" quarry of column charge standard blast with drill cuttings of the block No. 5 shown in Fig. 3 and Table 2. For the purpose of dust assessment metal dust collectors at the distance 50-150 m from the blast edge were installed. This dust formation assessment was interesting from the point of view of the influence of air shock waves on dust whirling-up from the surface of blasted rock mass.

The results of these investigations are presented in Fig. 4 and indicate that dust formation is decreased in 2 times while air-cushioned charge and gas dynamic equipment are applied as face cut.

By analogy with fallout of precipitation a model that permits to define zone of high pollution after massive blast have been developed. The Maximum Allowable Concentration (MAC) defines health and safety regulations for singular pollution of settlements. The pollution time shouldn't exceed 30 min. Taken it into account one can defines the plume length of surface pollution. It is formed in the process of above permitted standard shifting zone in the downwind pollution. This parameter depends on the blast power, type of explosive material, rock properties and blasting techniques the air condition and the surrounding ground as well. The length

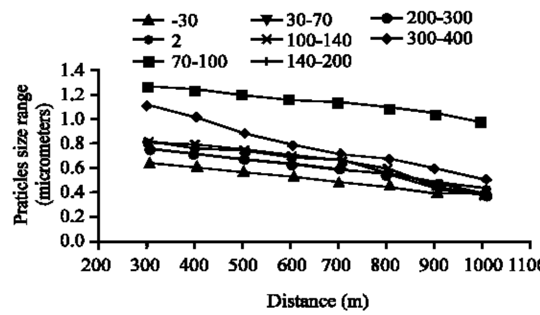

Fig. 2: The particle size distribution for the "Ostrovsky" quarry of column charge standard blast with drill cuttings of the block No. 1

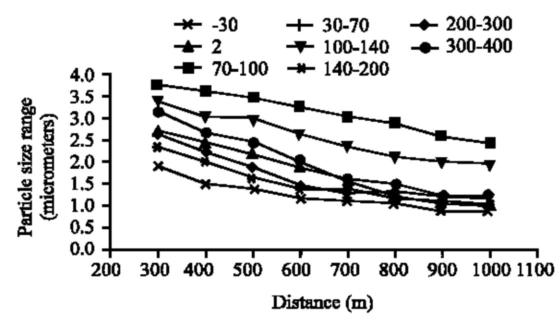

Fig. 3: The particle size distribution for JSC "Kamennogorsk" quarry for column charge standard blast with drill cuttings of the block No. 5

of petal is a maximum (Lc) under the most adverse conditions (high temperature inversion and zero wind). It should be kept in mind eight-point wind rose (North, North-East, East, South-West, West and North-West) in the calculation of High Pollution Zones (HPZ). In respect of Konorev, the length of the High Pollution Zones (HPZ) in the direction of each point is defined:

Table 1: The particle size distribution

	Range of particle size, micron (Dust mass, g/m^2)							
Distance from the blast (m)	-30	30-70	70-100	100-140	140-200	200-300	300-400	Total mass (g/m^2)
300	0.634	0.802	1.252	0.799	0.744	0.751	1.100	6.082
400	0.605	0.763	1.231	0.786	0.712	0.716	1.000	5.813
500	0.556	0.734	1.192	0.739	0.684	0.667	0.872	5.444
600	0.520	0.688	1.146	0.701	0.637	0.628	0.784	5.104
700	0.484	0.663	1.130	0.659	0.583	0.578	0.711	4.808
800	0.435	0.553	1.087	0.588	0.559	0.544	0.665	4.431
900	0.394	0.462	1.038	0.451	0.476	0.441	0.585	3.847
1000	0.367	0.429	0.969	0.378	0.390	0.388	0.496	3.417

Table 2: The particle size distribution

	Range of particle size, micron (Dust mass, g/m^2)							
Distance from the blast (m)	-30	30-70	70-100	100-140	140-200	200-300	300-400	Total mass (g/m^2)
300	1.8720	2.6897	3.7469	3.3690	2.3200	2.6352	3.1341	19.7669
400	1.4950	2.4110	3.5822	3.0030	1.9603	2.2023	2.6482	17.3020
500	1.3580	2.1529	3.4370	2.9852	1.6093	1.8536	2.4323	15.8283
600	1.1612	1.8446	3.2411	2.6100	1.3782	1.4400	2.0117	13.6868
700	1.1070	1.5778	3.0278	2.3300	1.3675	1.2705	1.5246	12.2052
800	1.0298	1.4500	2.8572	2.1000	1.1520	1.2764	1.1940	11.0594
900	0.8550	1.2131	2.5588	1.9905	1.0661	1.1854	1.0146	9.8835
1000	0.8605	1.2067	2.4000	1.9346	1.0028	1.1397	0.9573	9.5016

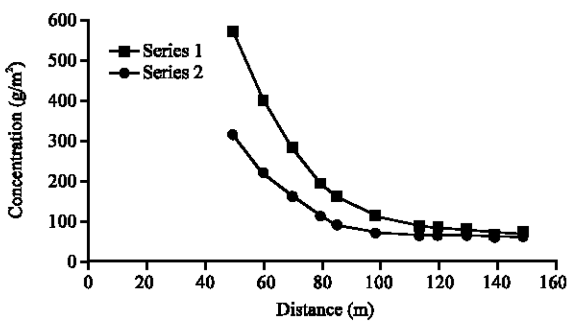

Fig. 4: The dependence of the deposited dust fraction of 0-200 micron from the distance at bore hole blast: 1-tested charge blast with air space and face cut of SGDU type; 2-standard charge blast with the face cut of boring silt

$$l_i = L_{oi}.P_i/P_o, \text{at } P_i > P_o$$
$$l_i = L_{oi}, \text{at } P_i < P_o$$

Where:

- P_0 = Wind repeatability of point at circular wind pattern ($P_o \approx 5$)
- L_{oi} = The length of petal wind in the point direction?

Dust fraction mass of the most dangerous for the environment and human is 20 micron $M_{1\Sigma}$ exuded at mass blast of 30000 kg anfo 70/30 while length is I_{charge} = 10 m and d_{CKB} = 252 with the following method (Beresnevich, 2001):

$$M_\Sigma = \int_0^9 M(\bar{r})d\bar{r} \text{ is } M_{1\Sigma} = 8.4 \text{ kg}$$

Where:

- $\bar{r} = R/R_0$ = Equivalent radius
- R_0 = Charge radius (m)
- R = Distance from the wellhead (m)

At mass blast ammonite No 6GW is $M_{2\Sigma}$ = 12.0 kg. The value of harmful gasses $V_{\Pi\Gamma 0}$ in gas and dust cloud from mass blast is $V_{\Pi\Gamma 0} = 0.895 \text{ m}^3/\text{kg} \times 30000 = 26850 \text{ m}^3$ and similar for both types of explosives. But concentration of 70/30 И ammonite No 6GW is different:

$$C_1 = \frac{8400000}{26850} = 313 \text{mg/m}^3$$

And:

$$C_2 = \frac{12000000}{26850} = 447 \text{mg/m}^3$$

Respectively while the Maximum Permissible Concentration of the fractions (MPC) CMPC = 0.15 m/gm^3 as a result of the excess of MPC, i.e., contrast ratio C_K:

$$C_{K1} = C_1/C_{MPC} = 2086.6 \text{ and } C_{K2} = C_2/C_{MPC} = 2980$$

High Pollution Area (HPA) in the direction of each point of the model studied for "Kamennogorsk" quarry the conditions are shown in Fig. 5.

By the example of JSC "Kamennogorsk" quarry, using the experimental data, we obtain the distance of ≈45 km from the source disordered blasting. It should be noted that the at blast operation causes the products such as dust, rock mass ejected in the explosion as well as the dust blown off the rock dumps and pit walls come into

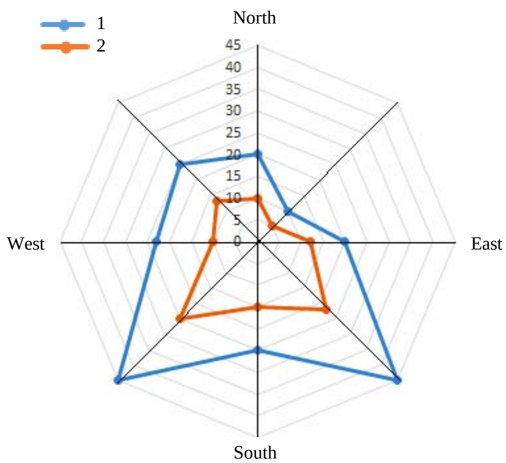

Fig. 5: High pollution area taking into account eight-point wind rose where 1 is the border zone in 1627 exceeded the dust MPC fraction of 0-20 mm, 2-zone border with MPC dust fractions of 0-20 mm

the atmosphere (Sasaoka *et al*., 2015). The composition of the gases produced during the blasting operation includes carbon monoxide and nitrogen oxides.

CONCLUSION

Thus, as a result of blasting operations inorganic dust: 70-20% SiO_2, NO_x Nitrogen Oxides (nitrogen (IV) oxide, nitrogen (II) oxide), Carbon Monoxide (CO) are liberated into the atmosphere. The investigations permit to conclude: the mass of the dust released during the blast operation decreases linearly with increasing distance from the quarry. The most predominant size of dust fraction in the dust and gas cloud is 70-100 mkm. At applying charges with the air gap and the locking gas-dynamic device as a dust tamping the dust formation is 45.6-28.6%. Taken into account eight-point wind rose the distance for the JSC "Kamennogorsk" quarry is about 45 km away.

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