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Analysis of Blasting Vibrations a different Blasting settings and Techniques

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ABSTRACT: Blast vibration is an important factor in determining the stability of an open-pit slope. Its negative impacts and impact on slope stability must be evaluated and investigated. Monitoring vibration with a blast is an effective technological instrument. The blasting vibration attenuation rule was obtained by regressing the site coefficient K value and attenuation index α value of the monitoring range using fitting analysis and sufficient data from critical locations. This provided a test basis for decreasing or limiting the harm caused by blasting vibration, as well as a basis for blasting design to increase mine safety during production.

Keywords: Blasting, Vibration, Test, Open pit mine and Impact.

1. INTRODUCTION

Blasting on a structure can cause a variety of problems, including noise, shock waves, airborne debris, toxic and hazardous gases, and vibration. A wide range of elements influence blast vibration, which can be divided into three categories: blasting source, propagation medium, and acceptor. The variables include source location, charge size, and geological structure. Internal factors include geological conditions, structural characteristics, and the acceptor's material qualities. The negative impacts of blasting stem from both the construction process and external causes. The "Technical code for slope engineering of non-coal open pit mine" (GB51016-2014) specifies the monitoring of blasting vibration. The "Blasting Safety Regulations" (GB6722-2014) establish detailed criteria for the primary vibration frequency and maximum vibration velocity in various types of buildings and structures. The velocity of ground particle vibration at various primary vibration frequencies is the most important component in estimating the impact of blasting vibration on ground buildings or structures.

2. BLASTING VIBRATION MONITORING

The primary goal of blast vibration monitoring is to determine the influence of blast vibration waves on surrounding buildings and structures. The capacity of the vibration wave to surpass the defined norm is evaluated using the prescribed criteria. A monitoring system often includes computers, storage devices, monitors, and sensors. Vibration parameters are divided into three categories: displacement, acceleration, and velocity. In theory, integral and differential equations can be used to convert vibration parameters such as displacement, acceleration, and velocity into each other. Every instrument has a limited monitoring range and resolution due to limits such as bandwidth, noise, linear error, sensitivity, and input and output amplitude. If the instrument's highest measured amplitude is 100 mm, an amplitude of 1 mm is regarded within the margin of error. As a result, the existence of noise and inaccuracy has made it difficult to accurately detect the low-amplitude frequency component when there is a high-amplitude frequency component present. To effectively oversee a project, it is critical to choose a suitable monitoring approach and establish an equitable measurement range that is consistent with the specific criteria. The device's sensitivity and measurement range are critical in determining the viability of gathering blasting vibration data. It is critical to follow the minimum requirements, especially for a speedometer, where the measured range should be given specific emphasis. There is a differential energy conversion mechanism between the input and output. When using the same input frequency, the output size is directly proportionate.

The relationship may be described as follows:

$$V_m = 2\pi f A_m$$

Vm, maximum displacement range.

m A , maximum displacement range of displacement pendulum.

f , frequency.

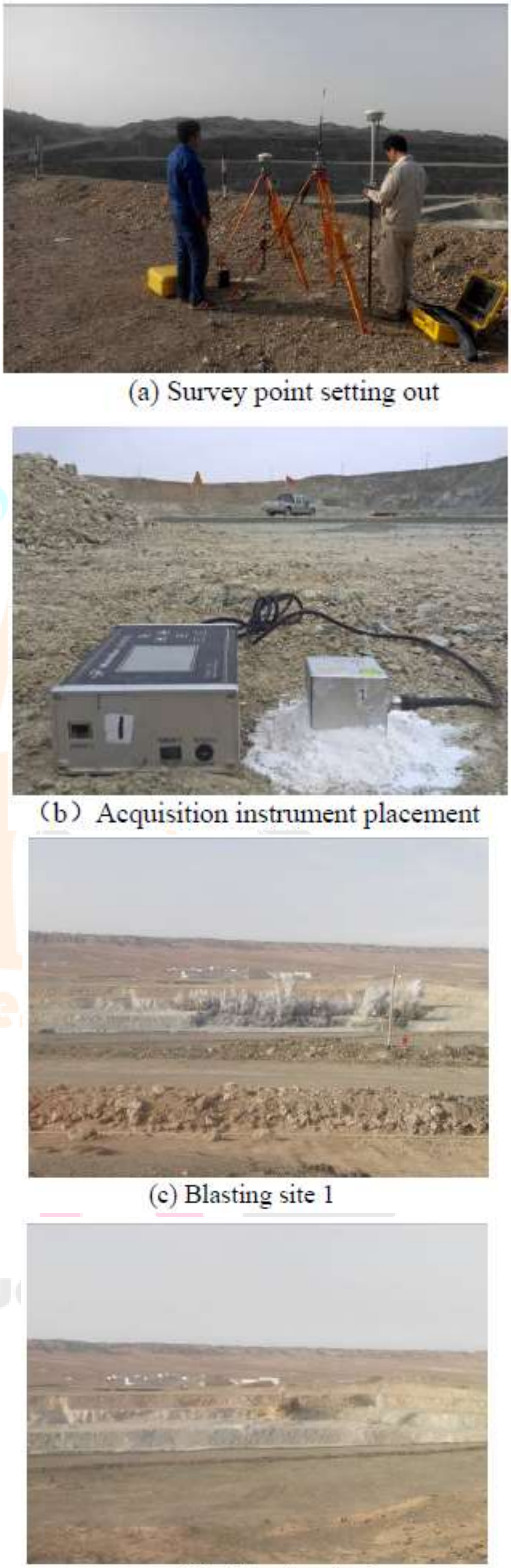
The mini blast I blasting vibration monitoring system was adopted in this stage of blasting vibration monitoring, its technical indexes are listed in Table 1.

Table 1. Technical indexes of mini blast I blasting vibration monitoring system.

Collection mode	Full parallel synchronous acquisition
Input impedance	1MΩ/20pF
A/D	24bit
Sampling rate	10000 sps
Dynamic range	100dB
Range	±10V
Measuring range	Vibration velocity 0.001～35cm/s, Frequency response 5～300Hz

3. DATA ANALYSIS

Following the "close dense and far sparse" idea, the six measuring stations were carefully placed in three distinct lithologic zones at the bottom of each step, taking into account the blasting location and the production state at the site. Figure 1 depicts four monitoring sessions that were held between March 22 and 23, 2016.



(a) Survey point setting out

(b) Acquisition instrument placement

(c) Blasting site 1

(d) Blasting site 2

Figure1. Field test.

The following is a brief summary of the monitoring data collected from each measuring point during the initial test:

Table 2. Monitoring data of typical measuring point in the first test.

Channel name	Maximum (cm/s)	Maximum time (s)	Half wave frequency (Hz)	Main frequency (Hz)	Range (cm/s)	Sensitivity coefficient (V/m/s)
X direction	0.0329	1.193	66.0	34.4	35.186	28.420
Y direction	0.2163	0.405	11.2	10.5	36.062	27.730
Z direction	0.0264	0.241	9.9	8.3	35.298	28.330

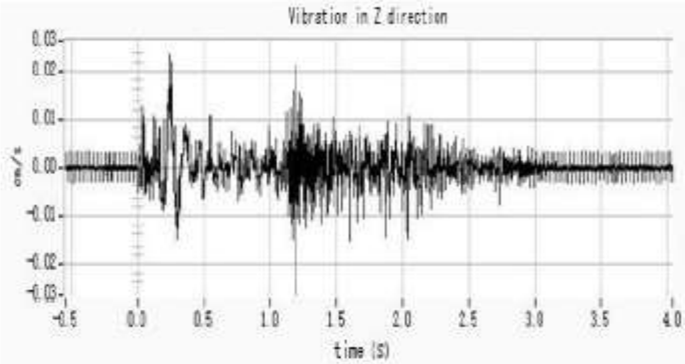


Figure 2. Typical waveform of typical monitoring point.

Table 3. Monitoring data of typical measuring point in the first test.

Point	Vibration measurer		Peak velocity (cm/s)	Main vibration frequency (Hz)	Maximum time (s)	Three direction synthetic velocity (cm/s)
1	0560	X	0.0130	18.1	1.1822	0.5245
		Y	0.5246	18.1	0.7054	
		Z	0.0088	18.1	1.1821	
2	0565	X	0.6296	25.5	0.2570	0.7908
		Y	0.2906	25.5	0.5376	
		Z	0.4346	18.5	1.3271	
3	0566	X	0.0333	34.4	1.1922	0.2165
		Y	0.2165	10.5	0.4042	
		Z	0.0258	8.3	0.2405	
4	0561	X	0.1887	18.6	2.4587	0.1777
		Y	0.1756	18.6	2.5334	
		Z	0.2085	10.4	2.5028	
6	3560	X	0.1006	10.6	1.15	0.1303
		Y	0.1033	18.9	0.28	
		Z	0.0982	10.4	1.13	
Total dose: 17600kg		Maximum dosage of single stage: 550kg			Hole diameter: 138mm	Hole depth: 13.0m

4. DATA FITTING ANALYSIS

Estimating the horizontal and vibrational velocity of particles Given certain seismic wave propagation characteristics, the blasting charge and the distance between the measuring site and the blasting source have the greatest influence on particle vibration velocity. A particle's peak vibration velocity is mathematically connected to charge, distance, site coefficient K, attenuation index α, and other factors.

$$V = K\left(\frac{Q^{1/3}}{R}\right)^{\alpha} = K\rho^{\alpha} \qquad (1)$$

V, Particle peak vibration velocity, cm/s. Take the maximum value of three component data;
Q, Explosive quantity, it is the total charge when blasting at the same time, millisecond delay blasting is the maximum charge, kg;
R, Distance between measuring point and center of explosion source, m;
K, Site coefficient, it is related to rock properties and blasting methods;
α, Seismic wave attenuation index, it is related to geological conditions;
ρ, Proportional dose,

$$\rho = \frac{Q^{1/3}}{R} \qquad (2)$$

To get the K and α values, convert the preceding attenuation formula into a linear connection, as V and ρ are non-linear. To get the following linear expression, use the logarithm function on both sides of the equation:

$$\lg V = \alpha \lg \rho + \lg K \qquad (3)$$

Given appropriate data, the least squares approach can be used to do regression on the aforementioned equations. For a collection of n sets of observational data:

$$\lg K = [\Sigma(\lg\rho \bullet \lg V) \times \Sigma \lg \rho - \Sigma \lg V \times \Sigma(\lg \rho)^2] / [(\Sigma \lg \rho)^2 - N\Sigma(\lg \rho)^2] \qquad (4)$$

K and α are obtained as follows:

$$K = 10^{\lg K}$$

$$\alpha = [\Sigma \lg\rho \times \Sigma \lg V - N\Sigma(\lg V \cdot \lg \rho)] / [(\Sigma \lg \rho)^2 - N\Sigma(\lg \rho)^2] \qquad (5)$$

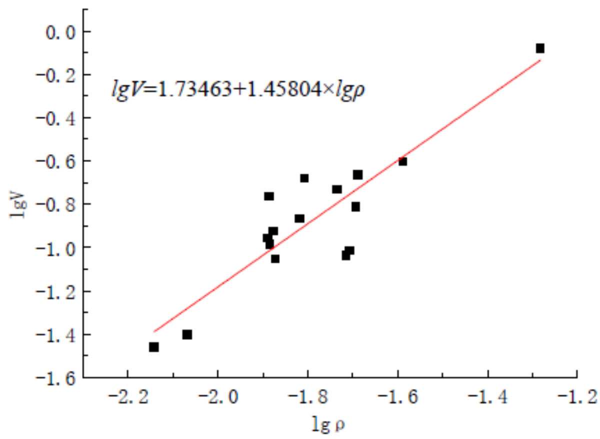


Figure 3. Particle velocity fitting line.

After removing noise from the data, K and α values were found to be 54.28 and 1.46, respectively. The attenuation law of blasting vibration particle vibration velocity was calculated inside the monitoring region.

$$V = 54.28 \times \left(\frac{Q^{1/3}}{R}\right)^{1.46} \quad (6)$$

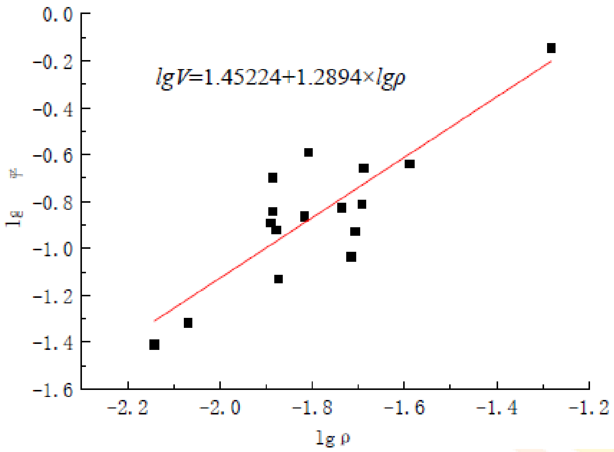


Figure 4. Linear fitting of particle horizontal velocity.

After removing noise from the data, K and α values were found to be 54.28 and 1.46, respectively. The attenuation law of blasting vibration particle vibration velocity was calculated inside the monitoring region.

$$_{\text{水平}} = 28.33 \times \left(\frac{Q^{1/3}}{R}\right)^{1.29} \quad (7)$$

Main vibration frequency fitting

The equation below demonstrates the fundamental relationship between the primary frequency of vibrations induced by explosions and the maximum amplitude of particle oscillation velocities:

$$\frac{fR}{V} = K\left(\frac{Q^{1/3}}{R}\right)^{\alpha} \quad (8)$$

The link between relative charge and relative velocity demonstrates that the principal oscillation frequency is directly proportional to both factors. Depending on the blasting conditions, particle maximum velocities at a given distance can vary greatly. The maximum particle velocity is directly influenced by site parameters, medium qualities, and geological conditions. The precise formula for determining the primary vibration frequency for open-pit deep hole blasting can be found in the blasting safety standards guide.

Based on the results of this test, it is critical to determine the relationship between the peak particle vibration velocity and the main vibration frequency of blasting vibration in order to accurately estimate the main vibration frequency. This relationship also has a significant impact on determining how blasting vibration impacts slope stability.

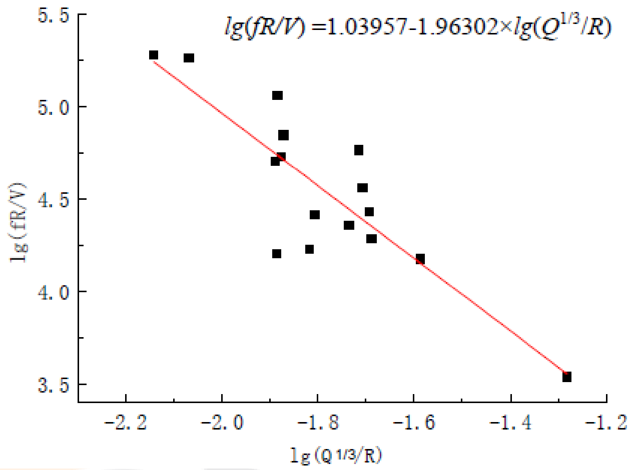


Figure 5. Frequency fitting straight line.

If

$$y = \frac{fR}{V},\ a = \lg K,\ b = \alpha,\ x = \lg\left(\frac{Q^{1/3}}{R}\right).$$

Then formula (8) can be transformed into a linear equation of one variable:

$$y = a + bx \quad (9)$$

Figure 5 shows the results of the regression analysis. Based on the curve fitting results, the following is the formula for the dominant vibration frequency:

$$f = 10.95 \times \left(\frac{V}{R}\right)\left(\frac{Q^{1/3}}{R}\right)^{-1.96} \quad (10)$$

Application of monitoring results

According to the technical code for slope engineering of non-coal open pit mines (GB51016-2014) and other national regulations, formula (6) should be used to guide each blasting design in compliance with the blasting vibration requirements of open mines. The design must strictly comply to the specifications provided.

The allowable vibration velocity at the base of the slope will serve as a warning indicator for blasting activities, and working slope stability can be maintained by utilizing the provided table to calculate the permissible vibration velocity.

Table 4. Allowable vibration speed

Risk level of slope landslide	Slope stability coefficient	Allowable vibration velocity (cm/s) controlled blasting
1	$F<1.05$	
2	$1.05\leq F<1.1$	22~28
3	$1.1\leq F<1.3$	28~35
4	$1.3\leq F$	35~42

During open-pit slope blasting, the particle vibration velocity on the side slope must be less than 24 cm/s.

5. CONCLUSION

The fitting technique resulted in the blasting vibration attenuation law. Using the given measuring points, four blasting vibration tests were performed with the blasting vibration monitoring system. Results [3][5] consist of the following: The vibrational impacts of blasting were significantly dependent on blasting settings and technique, rock mass composition, and local geological structure. As a result, due to the various processes and levels of influence, each location required its own analysis.

In a few circumstances, the blasting distance determined the maximum explosion intensity and distance. While maintaining the slope's distance from the surrounding site constant, limiting the maximum charge of a specific portion can assist lessen the superposition influence of blasting vibrations. The blasting operation resulted in some vibration, although multi-stage detonators served to mitigate it. After evaluating and fitting the data, a formula for the attenuation law was developed to characterize the propagation of blasting vibrations in the copper mine's monitoring zone. You can use this method to plan the blasting for your copper mine.

$$V = 54.28 \times \left(\frac{Q^{1/3}}{R}\right)^{1.46}$$

Blasting operations in open-pit mines must be designed in line with national legislation governing particle velocity of blasting vibrations in order to ensure slope stability and meet safety production objectives.

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