Analysis of blasting vibration transmission in waste dump

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1 PREFACE

There are many factors affecting the stability of dump, including stope blasting vibration. For blasting vibration, it has been studied for many years.

Duval, W. I. and Fogelson D. F. in United States Bureau of Mines and other scientists in the former Soviet Union and Sweden have done some research about the propagation of blasting seismic wave

The content includes the effects of vibration strength factors, propagation, failure criteria and so on.

Due to the blasting operation is quite frequent in mining process, the effect of vibration on stability of waste dump can not be ignored. When the dynamite explodes, the rock around the explosive charge will produce crushed circles and broken circles, The intensity of stress wave weakens rapidly after through the broken circles, and can only make the rock particle produce elastic vibration. Such vibration in the form of elastic waves propagating outward cause ground vibration, and it has certain influence to the mine side slopes, waste dumps and surrounding buildings.

2 ANALYSIS OF BLASTING VIBRATION ATTEN UATION OF WASTE DUMP

For the research of characteristics and regularity of blasting seismic wave, a small burst test and field test is still one of the most effective means. According to the measured data collection and statistics, an experience formula which is applicable to specific areas and blasting form can be fitted out, which can provide for prediction and calculation of blasting vibration. On this basis, the methods and measures to control the intensity of blasting seismic will be found. The physical quantities of description blasting seismic intensity include the particle displacement, velocity, acceleration and frequency. When selection ground motion parameters on the blasting engineering, the maximum values of particle vibration velocity caused by blasting on the surface becomes a judging standard of safety criterion of blasting seismic intensity.

At present, the common experience formula is Sadaovsk Formula, which is proposed by M. A. Sadaovsk who worked in Geophysical Institute of the USSR Academy of Sciences. The formula as following:

$$V = K\left(\frac{\sqrt[3]{Q}}{R}\right)^{\alpha} = K(\rho)^{\alpha} \tag{1}$$

In the formula: V is the maximum speed value of the blasting (cm/s); K is relevant coefficient which is associated with the transfer medium, blasting method, conditions and so on; α is the seismic wave attenuation coefficient related to the geological conditions; Q is the maximum priming charge of peak velocity values (kg); R is the straight-line distance between the measuring point and the explosive center (m); ρ is the proportion of priming charge,

$$\rho = \frac{\sqrt[3]{Q}}{R} \tag{2}$$

In the analysis, K and α are undetermined coefficients.

This formula is suited to the blasting vibration if the media of entire transfer process is uniform, but for waste dump，the media is non-uniform. Therefore, in this article, based on Sadaovsk Formula, the dump distance parameter R_2 is introduced, that is:

$$V = K\left(\frac{\sqrt[3]{Q}}{R_1}\right)^{\alpha} R_2^{\beta} = K(\rho_1)^{\alpha} R_2^{\beta} \tag{3}$$

In the formula：V, K, α and Q are the same physical meaning above; R_1 is the distance between the explosion center to the dividing line of waste dump and intact rock; R_2 is the distance between the measurement point in the dump to the dividing line of waste dump and intact rock; $\rho_1$is the proportion of priming charge; β is the attenuation coefficient of seismic wave in the waste dump;

3 CALCULATION OF EXAMPLE

In order to explain the reliability and rationality of the formula above, several blasting vibration effect field tests have been done in this article, and then the measured data have been analysed.

The measuring point arranges mainly considers two aspects, the most adverse impact section of blasting vibration to dump slope and the importance of slope. The computation sample establishes as dump $1^{\#}$, $2^{\#}$ and $3^{\#}$ arranges 4, 5 and 4 survey lines separately. According leaving explosion center from near to far, distributed along straight line. According to the data of blasting vibration obtained by the instrument, the raw data is processed by Matlab wavelet analysis, and the result is the peak speed of each measuring after filtering interference wave, which is the maximum vibration velocity. Figure 1 is the comparison of before and after the filtering process:

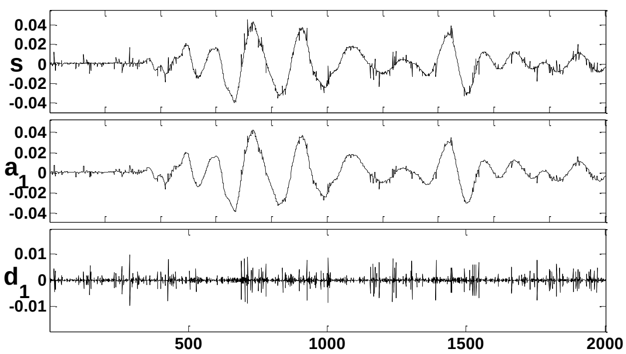

Fig. 1 Contrast map before and after filtering

S in the figure above is the original waveform of blasting, a_1 is the waveform after filtering. d_1 is the interference wave.

The form below lists the results of maximum section priming charge, distance from the explosion point and test result for each measurement point in dump:

Table 1 Parameters and result of each blasting test

Location	Number	Charge	Peak value V(cm/s)		Distance(m)	
		Q(Kg)	Level	Vertical	R_1	R_2
1# dump	1—1	1134.44	0.292	0.267	521.77	74.33
	1—2	1134.44	0.293	0.213	521.77	49.07
	1—3	1134.44	0.352	0.422	521.77	34.31
	1—4	1134.44	0.362	0.373	521.77	21.41
2# dump	2—1	1035.38	1.105	1.001	214.23	95.67
	2—2	1035.38	1.014	0.936	214.23	67.24
	2—3	1035.38	1.160	1.254	214.23	52.41
	2—4	1035.38	1.541	1.578	214.23	38.46
	2—5	1035.38	1.280	1.281	214.23	23.75
3# dump	3—1	3368.75	1.542	1.654	195.15	106.63
	3—2	3368.75	1.693	1.873	195.15	88.62
	3—3	3368.75	1.893	1.932	195.15	63.24
	3—4	3368.75	2.289	2.295	195.15	47.62

According to table 1, we have done bivariate regression analysis using the least square method for speed attenuation formula of waste dump:

The original equation is:

$$V = K\left(\frac{\sqrt[3]{Q}}{R_1}\right)^{\alpha} R_2^{\beta} = K(\rho_1)^{\alpha} R_2^{\beta} \tag{4}$$

Transforming the above equation, the equality left and right take the logarithmic separately:

$$\ln V = \ln K + \partial \ln\left(\frac{\sqrt[3]{Q}}{R_1}\right) + \beta \ln R_2 \tag{5}$$

Assuming:

$\ln V = Y$, $\ln K = a_0$, $\alpha = a_1$, $\beta = a_2$, $\ln\left(\frac{\sqrt[3]{Q}}{R_1}\right) = x_1$, $\ln R_2 = x_2$,

The formula 5 can be expressed as:

$$Y = a_0 + a_1 x_1 + a_2 x_2 \tag{6}$$

a_0, a_1, a_2 are the regression coefficients calculated.

According to the principle of method of least square, when the deviation between the measured values of field test of blasting vibration $Y' = \ln V'$ and the fitting values by formula is smallest (x_1', x_2' are also the measured values), a_0、a_1、a_2 are the right regression coefficients conforming to the formula. Therefore, the equation is transformed into solving the minimum of residual sum of squares between Y' and Y'', namely to solve the value of a_0, a_1, a_2 when M^2 is the minimum value.

$$M^2 = \sum_{i=1}^{n} (Y' - a_1 x_1' - a_2 x_2' - a_0)^2 \tag{7}$$

According to the extreme value theorem of binary function, the condition for M^2 getting the minimum is:

$\frac{\partial M^2}{\partial a_0} = 0$、$\frac{\partial M^2}{\partial a_1} = 0$、$\frac{\partial M^2}{\partial a_2} = 0$

The formula launches to obtain:

$$\left.\begin{aligned} \sum_{i=1}^{n} x_1'(Y' - a_1 x_1' - a_2 x_2' - a_0) = 0 \\ \sum_{i=1}^{n} x_2'(Y' - a_1 x_1' - a_2 x_2' - a_0) = 0 \\ \sum_{i=1}^{n} (Y' - a_1 x_1' - a_2 x_2' - a_0) = 0 \end{aligned}\right\} \tag{8}$$

And at last we will obtain the unique solution of unknown regression coefficients a_0、a_1、a_2. The form below lists the various parameters obtained by the binary regression analysis and speed attenuation formula of waste dump:

Table 2 Parameters and fitted formula

Direction	K	α	β	speed attenuation formula
Vertical	124.01	1.177	-0.2607	$V_V = 124.01\left(\frac{\sqrt[3]{Q}}{R_1}\right)^{1.177} R_2^{-0.2607}$
Level	113.97	1.143	-0.2697	$V_L = 113.97\left(\frac{\sqrt[3]{Q}}{R_1}\right)^{1.143} R_2^{-0.2697}$

4 CONCLUSION

(1)The speed attenuation formula of waste dump in this article is based on the Sadaovsk Formula. By analyzing the non-uniformity of media, the R_2^{β} is added, which is the influencing factor of loose deposits to transmission of vibration. This formula can objectively describe the transfer characteristics of the vibration in the dump;

(2)According to the analysis of experimental data, vertical velocity is generally higher than the level caused by blasting vibration transfer in the blasting process. Therefore, vertical velocity is one of the main factors to cause the instability of waste dump;

(3)If the priming charges are same, according to the number of α and β, the influence of R_2 is much larger than R_1. The result can explain that effect of the blasting vibration on rock mass is bigger than waste dump.

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