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Research Article

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Spectrum analysis of controlled blasting vibration

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ABSTRACT

Accurate delay blasting with electronic detonator can be used to make the main band frequency of energy distribution move towards high-frequency and the distribution trend will be more homogenized when foundation excavation of deep hole controlled blasting used in the complex environment. The method of EEMD (Ensemble Empirical Mode Decomposition) can be used to signal analysis, then analyze the main band frequency of blasting vibration energy distribution, which illustrate that blasting main frequency band of vibration energy appeared in 15 - 45Hz. Blasting vibration energy distributed in the frequency band below 10Hz less than 4.5% of the total energy of the following, which effectively avoided the low-frequency vibration damage of buildings.

Key words: WSN blasting vibration; Electronic detonators; accurate delay; EEMD;

INTRODUCTION

Blasting seismic effect is the major hazards in the complex environment of controlled blasting engineering, electronic detonator delay time, high precision, have been widely used in various types of blasting works. Site combined presplit blasting, strict control of blasting vibration and vibration blasting areas surrounding buildings safety analysis. EEMD method was used to analysis blasting vibration signal velocity, frequency and energy distribution and variation with frequency of each measuring point [1-3]. The energy distribution of blasting vibration signal frequency band was introduced in building protection research, which can provide a method to research the safety problem of blasting vibration.

DETECTING SYSTEMEXPERIMENTAL DESIGN

Project overview

Due to limited space, the north and west sides of the mountain need to excavation expansion, after excavating surface coating, the lower need for blasting rock excavation, an area of about 13,500 m^2, with an average depth of under 7 to 8 m digging, blasting square about 6000 m^3, used dynamite about 2500 kg. Figure 1 and 2 shows the monitoring arrangement.

Fig. 1. Blasting site

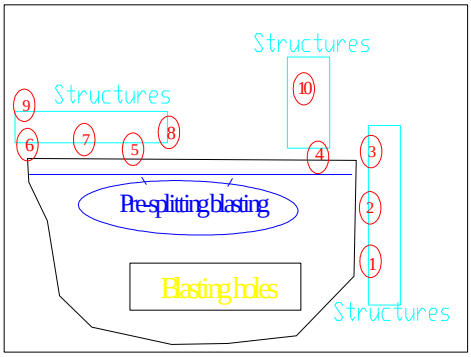

Fig. 2. Monitoring arrangement

Blasting and monitoring arrangement scheme

In the program of precision delay hold-by-hold blasting all detonator is electronic detonator, to ensure the safety of buildings near the site, between the main area and the reserved area formed a crack by presplit blasting, achieve the purpose of damping. Total explosive of the blasting about 3600 kg, pre-hole hole maximum explosive 10 kg, bore no coupling charge, pre-hole pitch 0.8 m, row spacing 2. 3m. Pre-hole before the main blast holes 70 ms initiation, the number of holes is 33, a group of three holes, each group with the same delay time about 3ms. Maximum dose main blasting hole is about 21kg, pitch 3m, row spacing 2.5 m, taken with hole extension and bore extension combined.

Blast vibration signal monitoring results

According to the topography and surrounding buildings protected needs were arranged 10 monitoring points, used three blasting vibration to the sensor signal monitoring, Table 1 shows the blast vibration signal detection.

Table.1Table of blasting vibration monitoring results

Measuring point number	Horizontal tangential	Horizontal radial	Vertical	Horizontal tangential	Horizontal radial	Vertical	Thedistance to explosion center /m	Elevation difference with the explosionbottom source/m
	Velocity /(cm·s^{-1})			Frequency /Hz				
1	1.21	0.98	1.36	19.2	18.4	21.8	39	3
2	1.19	0.97	1.25	19.1	18.8	21.0	39	3
3	0.83	0.78	0.59	15.6	18.7	15.3	47	3
4	4.65	3.83	3.82	30.6	18.3	16.5	15	7
5	4.18	2.66	2.2	28.4	21.0	24.7	28	7
6	1.22	1.09	1.03	18.4	17.9	18.9	35	7
7	0.64	0.58	0.52	20.8	21.2	18.2	47	7
8	0.39	0.40	0.35	23.6	22.4	24.1	47	7
9	0.41	0.29	0.30	23.9	21.2	23.8	52	7
10	0.3	0.43	0.32	20.6	18.4	20.5	59	7

Measuring point 1, the measuring point 2, the measuring point 3 are located blasting zone side, share the same elevation ,three direction peak particle velocity are under the safety standards. Measuring point 4 to measuring point 10 is located behind the blast zone, the same elevation, and opposite the blast throws direction, generally blasting vibration velocity behind area is larger. Brick houses from the measuring point 4 is only 15m,and it's ground velocity peak in three directions at 10 measuring points is the largest, horizontal tangential velocity is 4.18 cm/s, significantly greater then horizontal radial and vertical velocities. Under the same conditions in elevation, the peak velocity magnitude of particle decreasing with the distance of monitoring between explosion source center increases, in addition to measuring point 8 and the measuring point 10, the remaining eight measuring points signal levels tangential velocity is greater than the other two directions velocity. Consider the impact of elevation difference, measuring point 3, measuring point 7, measurement point 8 have the same distance away from the explosion center, blasting vibration signal frequency increases with elevation.

All signals' frequency of 10 measuring points around the 20Hz, no significant change in the law, indicating that the use of electronic delay detonators precise hole by hole initiation can be well control blasting vibration frequency. Based on "Blasting Safety Regulations", the maximum velocity of such a house shall not exceed 2.8cm/s, the peak velocity of measuring point 4, measuring point 5 have exceeded the safety standards, but after blasting these houses haven't destroyed, to be combined with multiple factors analysis.

Because of the self-oscillation frequency of building (structure) is generally low, so reducing low frequency vibration energy and improving energy distribution of the signal frequency band is very important [4-6], using

electronic detonators precision delay master detonating can reduce vibration superimposed , avoid excessive peak velocity and improve vibration signal frequency [7]. Blasting vibration depends on the time, frequency and velocity, get them together is blast vibration energy [8], followed by EEMD method used to analyze the characteristics of signal energy.

SIGNAL ENERGY DISTRIBUTION

Blasting vibration Energy distribution

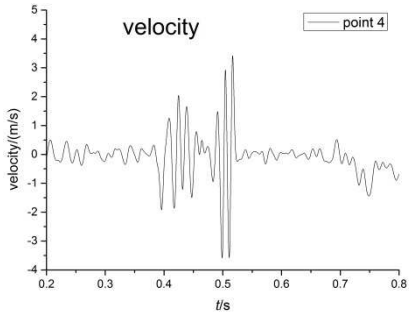

Fig. 3. Waveform monitoring point 4

It can be seen in Figure 4, as electronic detonator precise delay, a plurality of signal peaks occur, except significantly larger two peaks at the beginning 0.29 s, analyzing of peak time, considering the pre-hiatus closer to measuring point 4, the signal maximum peak is presplit blasting vibration signal. After the pre-split blasting, the signal of the main area of blasting exhibits advantages of hole by hole initiation of controlling blasting vibration speed, and avoids signal superimposed to form a too large peak . Figure 5 is the blasting vibration signal horizontal tangential component of the marginal energy spectrum of a monitoring point 4.

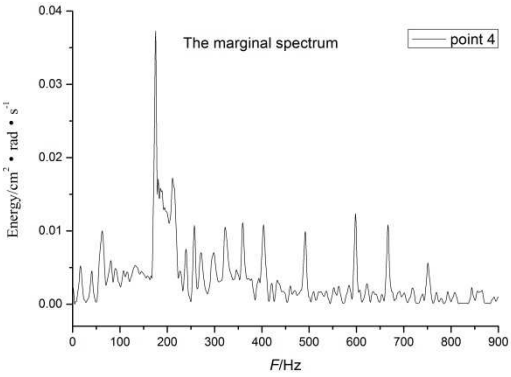

Fig. 4. Marginal energy spectrum

As can be seen in Figure 5, the frequency band of the signal energy distribution at 17.6 - 38.2 Hz, the energy below of 10 Hz frequency is less can be effectively reduced resonance hazards. Figure 6 is the blasting vibration signal horizontal tangential component of the dimensional energy spectrum of a monitoring point 4.

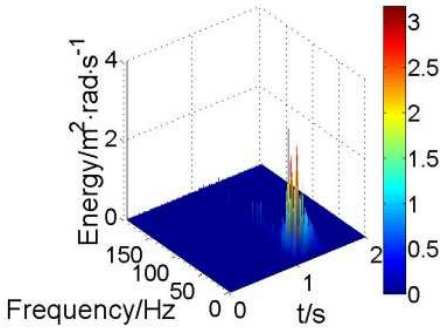

Fig. 5. Three-dimensional energy spectrum

Analysis of Figure 6, less energy is distributed in the low frequency band, and more uniform. Blasting vibration energy is dispersed throughout the frequency domain, which is good to avoid a certain frequency band energy too

concentrated, particularly reducing the energy distribution in the low-frequency close to the building's the natural frequencies. Figure 7 is blasting vibration signal energy distribution of the tangential component of the monitoring point 4.

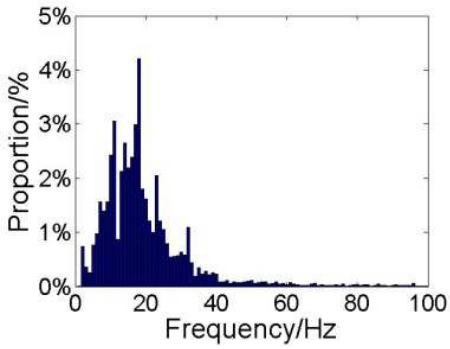

Fig. 6. Energy proportion

Use the marginal energy spectrum calculations energy distribution, using the histogram to represent the distribution of vibrational energy ratio. Energy from the beginning 17.6 Hz significantly increased and the distribution over 40 Hz rare, the signal bands below 10 Hz accounted for 3.3% of the total energy, vibrational energy distribution is very small.

Below 10 Hz frequency band energy as the low-frequency energy, because building (structure) vibration frequency is low, so low-frequency energy is smaller and lower of the ratio of signal energy accounted the better for the protection of building (structure). Electronic detonator hole by hole blasting let only a small portion of the vibration energy distributed in the low-frequency band, effectively dispersed low frequency energy destructive [12].

At the same elevation, the low frequency component of the signal energy ratio at every direction of increases with distance. Signal largest proportion of low-frequency energy at vertical, horizontal radial followed, the minimum level of tangential.

In this blasting the peak particle velocity of the measuring points 4 and 5 exceeds the safe allowable value, but after reconnaissance found no damage to the building, according to the frequency band blasting energy calculations, the range of blasting vibration frequency energy buildings greater than the natural frequency and low frequency below 10Hz band energy is less than 4.5% of the total energy, , although the velocity is exceeded, but the energy of low frequency less and vibration of short duration will not cause damage to buildings.

Energy distribution of the frequency band

Table.2 Energy distributionFrequency band of blasting vibration

	Energy distribution of the Frequency band									
Signal No.	1	2	3	4	5	6	7	8	9	10
Horizontal tangential/ Hz	16.2-40.3	17.1-40.9	16.6-34.5	17.6-38.2	20.5-43.7	17.4-39.8	16.8-36.4	17.6-35.1	16.9-35.6	15.6-33.1
Horizontal radial/Hz	18.4-36.7	16.8-37.2	17.7-37.3	18.3-34.7	17.7-39.1	17.9-38.6	18.2-43.4	17.4-37.1	17.2-33.8	16.4-36.9
Vertical/Hz	14.8-30.6	15.0-34.6	15.3-35.8	15.5-41.2	16.9-35.7	18.9-40.3	16.2-33.7	14.1-35.1	15.8-37.0	13.5-33.3

The use of electronic detonator precise delay control of blasting vibration signal energy in frequency band 15 - 45 Hz, frequency distribution of energy with the distance increasing of the measuring point between the heart of burst with frequency to bring lower tended to decrease, roughly the same distribution range of the band width of about 20 Hz. Conducted several blasting at the same site conditions and the measurement point, contrast with the ordinary millisecond delay detonator, the electronic detonators, blasting vibration energy is significantly higher than frequency band. In the same conditions of explosive center distance, with the increasing of elevation frequency energy distribution can improve, helping to protect the building, but because of the amplification of elevation on velocity, must strictly control the velocity.

According to the calculation of the components of the energy distribution of frequency band energy used in this

component of the proportion of 90% or more monitoring points 4 energy distribution of frequency band energy used in horizontal tangential component of the energy 92.7%, monitoring points 4 horizontal tangential component of the energy representing the signal of the total energy were 47.2%.

CONCLUSION

Electronic detonators precision delays hole by hole blasting can make frequency and energy develop to the high frequency distribution and have a trend of more uniform distribution. Blasting vibration signal energy distribution in frequency band 15 – 45 Hz, higher than the building natural frequency of vibration can be reduced damage to buildings. Frequency band component signal energy distribution which accounted for over 90% of the total energy, the size of the upper and lower frequency band is important to vibration safety.

Elevation increases will increase the energy distribution of blasting vibration signal frequency band; At the same elevation, the direction of the low frequency component of the signal energy ratio increases with distance, 10Hz low frequency band energy less than 4.5% of the total energy.

Particle velocity not the only parameters judge of whether the buildings damaged by vibration, building blasting vibration security related to the cumulative effect of blasting vibration, it's more reasonable study the vibrational energy distribution safety issues by energy distribution ratio of frequency bands.

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