Analysis of blasting vibration and disturbing vibration

Zhenjiao Sun *, Hongyuan Zhao and Xinyu Ji
Shandong University of Science and Technology, Qingdao 266590, China.

*Corresponding author e-mail: 1710896764@qq.com.

Abstract. A large number of vibration data are compared and analyzed in various environmental ground conditions by using the measured data of a large number of vibration measured in the station of the Qingdao Metro and the station West Town, the falling of the objects, the personnel passing through, the knocking on the ground, incorrectly triggering the sensor and the continuous contacting surface of the object. The "vibration decay time" is defined as the time when the maximum value of the wave appears in the vibration velocity diagram until the maximum value of the wave is stabilized to less than 10% of the maximum value. The following conclusion is drawn: if the vibration decay time is lower than 0.1s, it can be judged to be a non-blasting vibration. When the vibration decay time is above 0.1s, the Fourier transform is simplified and its amplitude spectrum is obtained. If the excellent frequency band is 130Hz~230Hz, it is blasting vibration. If the excellent frequency of vibration is larger than 450Hz, it is a disturbing vibration.

Keywords: blasting vibration; disturbing vibration; FFT transform; amplitude spectrum.

1. Introduction
Urban subway is playing a more and more important role in the three challenges facing "population explosion, shortage of land resources and environmental deterioration", which is not occupied by land resources. As the social and economic level of China is more and more developed, the vibration damage caused by subway excavation blasting on the surface buildings and structures has been paid more and more attention. The blasting vibration effect will be influenced by many factors such as the characteristics of the explosion source, the blasting method, the terrain and the geomorphology, the properties of the rock and soil and other factors, which make the analysis of the blasting vibration law more difficult [1~7]. The vibration problem in subway construction has also become the focus of attention and research. Therefore, it is necessary to analyze the blasting vibration and disturbing vibration, find out the distinction point, eliminate the interference of interference waveform, and facilitate the late processing of blasting waveform.

In recent years, researchers at home and abroad have conducted in-depth discussions on vehicle and other interference factors from theoretical analysis, numerical simulation and experimental measurement, and achieved relatively good results. Zhou believed that the spectral curve of the explosion shock wave showed an overall attenuation trend with the increase of the detonation center distance [8]. However, no studies have been conducted on the vibration interference of falling objects at high altitude. In addition, taking the construction site of Qingdao undersea tunnel as an example, in
order to collect data, the vibration meter is often placed at the measurement site for two to three days, and the situation that the interferential vibration triggers the sensor of the vibration meter by mistake occurs frequently [9]. Therefore, it is very important to carry out this work.

In this paper, the blasting vibration and non-blasting vibration caused by human trampling were measured on the spot during the construction of Qingdao metro drilling and blasting method, and the amplitude spectrum was obtained by FFT transformation. The difference between ground vibration caused by blasting and interference vibration is analyzed.

2. Experimental design of blasting vibration

2.1. Experimental instrument and layout of measuring point
This test instrument is TC-4850 blasting vibration meter. The trigger level is set to 0.01cm/s.

The measuring point is located at the construction site of the West Town station in Qingdao. The measuring point two is located at the Qingdao Cross Tunnel station.

![Figure 1. Diagram of blasting vibration monitoring site](image)

Since the sensor must be rigidly connected to the object under test when it is installed on site, the test accuracy will be affected. According to the actual situation, two kinds of ground environments were measured respectively on ordinary land surface and cement ground. Because the plaster binder was used for fixed installation in this experiment, when installing the sensor on the ordinary land surface, half of the sensor was buried in the ground to ensure the rigid connection.

2.2. Field experimental parameters

2.2.1. Experimental parameters of falling objects. In this experiment, a heavy 100g steel ball was selected, and the experiments of falling objects at various heights were carried out at the distance of 1 meters from the vibrometer sensor, and repeated experiments were carried out.

2.2.2. Experimental parameters of personnel passing through. In this experiment, a person weighing 60 kg was selected to walk around 1 m from the vibrometer and the experiment was repeated.

2.2.3. Experimental parameters of object continuous contacting with ground. In this experiment, a person was selected to drag a weight of 20 kg and passed the distance of 1 meter from the vibrometer sensor, and the experiment was repeated.

2.2.4. Experimental parameters of the person accidentally touching the sensor. In this experiment, a steel ball weighing 100g was selected, and a certain force was applied at a position 1 meter away from the sensor of the vibrometer to cause it to roll against the sensor and repeat the experiment.
2.2.5. *Experimental parameters of tapping the ground.* In this experiment, a 100g elastic ball was released at a certain distance directly above the sensor to knock the vibrometer to simulate the person tapping the sensor and repeat the experiment.

3. **Analysis of vibration test results**

3.1. *Vibration velocity image analysis*
Representative data analysis is performed in a large number of vibration data in various cases to obtain a vibration velocity diagram as follows:

![Figure 2](image2.png)  
*Figure 2.* speed diagram of object continuous contacting with ground

![Figure 3](image3.png)  
*Figure 3.* speed diagram of tapping the ground

![Figure 4](image4.png)  
*Figure 4.* speed diagram of personnel passing through

![Figure 5](image5.png)  
*Figure 5.* speed diagram of falling object

![Figure 6](image6.png)  
*Figure 6.* speed diagram of false touching sensor

![Figure 7](image7.png)  
*Figure 7.* speed diagram of blasting vibration
The waveforms in Figures 2 to 7 are analyzed. Here, the time when the maximum amplitude of the wave in the vibration velocity diagram occurs until the maximum value of the wave is stably lowered to 10% or less of the maximum amplitude is defined as "vibration decay time". The "vibration decay time" in each case was counted for all test data.

Table 1. The vibration recession time of various vibration velocity waveforms

| Form of vibration                             | The vibration recession time |
|-----------------------------------------------|------------------------------|
| Blasting                                      | > 0.22s                      |
| Knocking on the ground                        | 0.021~0.030s                 |
| Personnel passing through                     | 0.054~0.067s                 |
| Object dropping                               | 0.031~0.042s                 |
| Incorrectly triggering the sensor             | 0.025~0.029s                 |
| Object continues to touch the ground friction | > 0.26s                      |

It can be seen from Table 1 that the vibration caused by falling objects, people passing by, hitting the ground and accidentally touching the sensor is quite different from the vibration caused by blasting. The "vibration decay time" of blasting vibration is above 0.22s, and the "vibration decay time" of other interfering vibration is below 0.08s. Therefore, it can be used as an index to distinguish blasting vibration from interference vibration. However, there is no significant difference between the vibration of an object in continuous contact with the ground and the vibration decay time of a single blasting vibration. The amplitude spectrum is analyzed.

3.2. Amplitude spectrum analysis

Simplified Fourier transform is performed on the vibration velocity diagram of blasting and object grinding under various parameters, and a typical image is obtained as shown in Fig. 8~9.

It can be seen from Fig. 8 to Fig. 9 that the excellent frequency band of the vibration generated by the blasting is more distinct from the continuous contact of the object with the ground. Therefore, it can be used as a distinction.

According to a large number of actual measurement data, the excellent frequency range of blasting vibration is 130Hz~230Hz, and the excellent frequency band of objects continuously contacting the ground vibration is greater than 450Hz.
3.3. Waveform analysis directly
When the vibrometer is placed on the ground, that is, above the face of the face, the interfering vibration can be directly distinguished according to the waveform.

![Figure 10. the vibration waveform of the ground by knocking on the ground](image1)

![Figure 11. the vibration diagram of blasting](image2)

It can be seen from the comparison of Fig. 10 to Fig. 11 that when the vibrometer is arranged on the ground, the vibration velocity in the Z-axis direction of the waveform diagram is significantly higher than the X and Y axes, and the Z-axis direction in the waveform diagram of other disturbing vibrations. The vibration speed is much smaller than the vibration velocity in the other two directions.

4. Conclusion
Through the comparative analysis of the vibration data, the following conclusions are drawn:

1. If the "vibration decay time" of the vibration is less than 0.1 s, it can be determined as an interfering non-blasting vibration.

2. When the "vibration decay time" of the vibration is above 0.1 s, the simplified Fourier transform is performed to obtain the amplitude spectrum. If the vibration excellent frequency band is 130 Hz to 230 Hz, it is blasting vibration; if the vibration excellent frequency band is 450 Hz, it is an interfering non-blasting vibration.

3. When the vibrometer is placed on the ground, the vibration velocity in the Z-axis direction on the waveform diagram is significantly higher than the X and Y-axis, while the vibration velocity in the Z-axis direction of other interfering vibration waveforms is much smaller than the other two directions.

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