# Experimental Study on the Effect of Damping Ditch on Reduction of Blasting Vibration in Urban Area Short-hole Controlled-blasting

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**Key Words:** Short-hole controlled-blasting; Damping ditch; Blasting vibration effect; HHT

**Abstract:** Blasting vibration effect is one of the main harms in engineering Blasting, and damping ditch is a most important technique measures in reducing the influence of blasting vibration. Supported by a project, this thesis collected field data of blasting vibration in the excavation, and then uses the acquired data to analyze the general rules of damping ditch as a measure in reducing the influence of blasting vibration. It turned out that we can achieve sound result in reducing the influence of blasting vibration, changing the vibration wave frequency structure, energy spread and protecting the surrounding building structures by choosing parameters appropriately.

## Introduction

In towns, rock blasting methods are often used in the process of excavation of foundation pit, blasting technology brings to the construction with efficient, economic, convenient and at the same time also brought some negative effects of disasters, in which headed by the harm from the blasting vibration effects[1]. In the town, around the foundation pit which needed to be excavated generally have a both dense municipal facilities and residential housings and the safety distance is limited, when the blasting technology used for rock excavation, blasting vibration wave spread through the rock mass to the building structures around, making the building structures produce dynamic response under the action of blasting vibration, this will not only cause damage to surrounding building structures, but also can cause a dispute that might affect the project smoothly. Therefore, it is necessary to study how to control town Short-hole controlled-blasting vibration effect.

Through the research on the rules of blasting vibration, engineering taken various effective measures to control and reduce the blasting vibration damage, the excavation of the damping ditch is one of the effective methods to reduce the blasting vibration damage, it is easy to construction, now is widely adopted [2]. Damping ditch's mechanism of shock absorption is mainly to cut off and interfere with the vibration wave propagation, to speed up the vibration wave attenuation, reduce the strength. Vibration reflection and diffraction when it passed damping ditch, thus accelerate the blasting vibration wave attenuation [3-4]. The domestic and foreign scholars have conducted a lot of research on the damping ditch damping mechanism. Hagimori [5] etc through the contrast test research under the situation with or without damping ditch, results show that damping ditch damping effect reaches 60% to 80%.Fang Xiang [4] etc conducted 24

times blasting experiment under the condition with or without damping ditch and carried out based on the measured data of waveform analysis, spectral analysis, regression analysis, summarizing the influence laws of damping ditch to the duration of blasting vibration intensity, the vibration wave frequency and the vibration waves. Yi Chang-ping[3] etc using ANSYS LS-DYNA to simulate the damping ditch excavation position and excavation depth on the relationship between the damping effects. This article tries to combine the rock and soil blasting engineering measured data, Using HHT method to analysis frequency band energy of blasting vibration signals. Using the Hilbert transform each signal, then we get the original waveform figure, the instantaneous energy spectrum, energy distribution. This paper makes a deep study on the damping effect of the damping ditch and the optimum range of vibration reduction eventually.

## Project design

### Blasting scheme

In order to research damping ditch's function of Vibration reduction, choosing one of the blasting vibration data of blasting excavation of foundation pit to analysis. The geological conditions of foundation pit for the marl, the hole diameter of blasting excavation is 40mm, the depth of the hole 2.5m, packing height is 1m, the minimum resistance line 1m, using instantaneous detonator initiation of one-time initiation mode. There is a damping ditch between the protected building and the blasting area with 3.5m depth and 8m wide. Blasting area is located in the left side of damping ditch and 35 m away from damping ditch, protected buildings located in the right side of damping ditch and distance it 3 to 10 m. Blasting area surrounding environment is shown in figure1

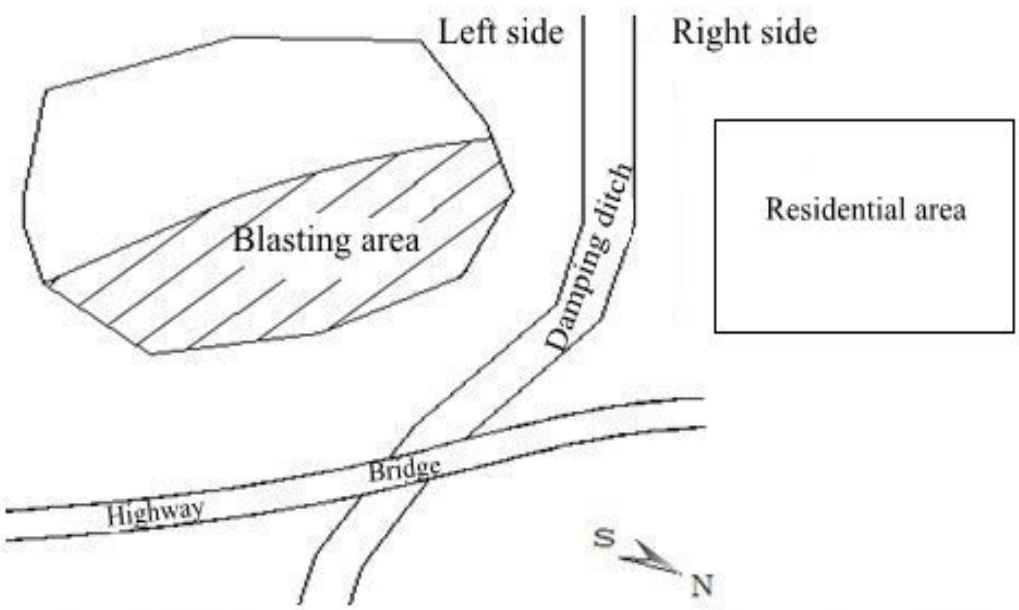



**Fig.1 Schematic diagram of the blast area surrounding environment**

### Test plan

According to the actual situation and the data analysis needs, there are six test points assigned along the damping ditch on the right side in this test, test points to the damping ditch were the

distance of 10 meters, 6 meters and 3 meters, each test point need to measure 3 component of the peak particle vibration velocity and main vibration frequency. Before the sensor be arranged, all the lines connected of six points' overburden need to be dig out, exposed bedrock, placement test point on the bedrock, and then the selected point grinding with a grinding machine, the sensor was bonded on the measuring point with a mixture of glue and plaster. Make sure that the blasting vibration test instrument before use, the system has been synchronized time.

## Measured data processing and analysis

### Studying damping ditch's influences on particle peak vibration velocity

This blasting test uses the TC - 4850 type blasting vibration tester, it can measure the vertical and the radial and tangential component of three directional blasting vibrations. To meet the needs of engineering practice and data analysis, this test need to measure the X direction, Y direction and Z direction of the peak particle vibration velocity and the main vibration frequency. The measured blasting vibration data as shown in table 1.

Table 1 The measured blasting vibration data

| Serial number | Peak particle Vibration velocity (cm·s-1) | | | Main frequency of vibration （Hz） | | | blasting center distance （m） | Total Quantity （kg） | Measuring point location | Protected Object position |
|---|---|---|---|---|---|---|---|---|---|---|
| | x | y | z | x | y | z | | | | |
| 1-1 | 0.122 | 0.116 | 0.116 | 14.760 | 12.403 | 12.924 | 97 | 22.2 | R 10m | R 10m |
| 1-2 | 0.118 | 0.130 | 0.165 | 14.134 | 10.076 | 13.158 | 97 | 22.2 | L10m | R 10m |
| 2-1 | 0.184 | 0.135 | 0.118 | 30.651 | 11.817 | 12.821 | 72 | 12.7 | R 6m | R 6m |
| 2-2 | 0.210 | 0.13 | 0.353 | 10.681 | 7.030 | 12.214 | 72 | 12.7 | L 6m | R 6m |
| 3-1 | 0.061 | 0.072 | 0.120 | 8.299 | 8.574 | 22.039 | 73 | 12.8 | R 1m | R 3m |
| 3-2 | 0.271 | 0.233 | 0.244 | 13.722 | 14.286 | 11.61 | 73 | 12.8 | L 1m | R 3m |

Taking measured data into Blasting vibration analysis software with vibration tester, according to the characteristics of blasting vibration wave, it is easy to eliminate error waveform caused by outside interference, then 6 groups of the measured Blasting vibration wave can be obtained, this article will only analyze measured blasting vibration wave which is 1 m distant from the right side of damping ditch listed, the blasting vibration wave diagram as shown in figure 2 and figure 3.

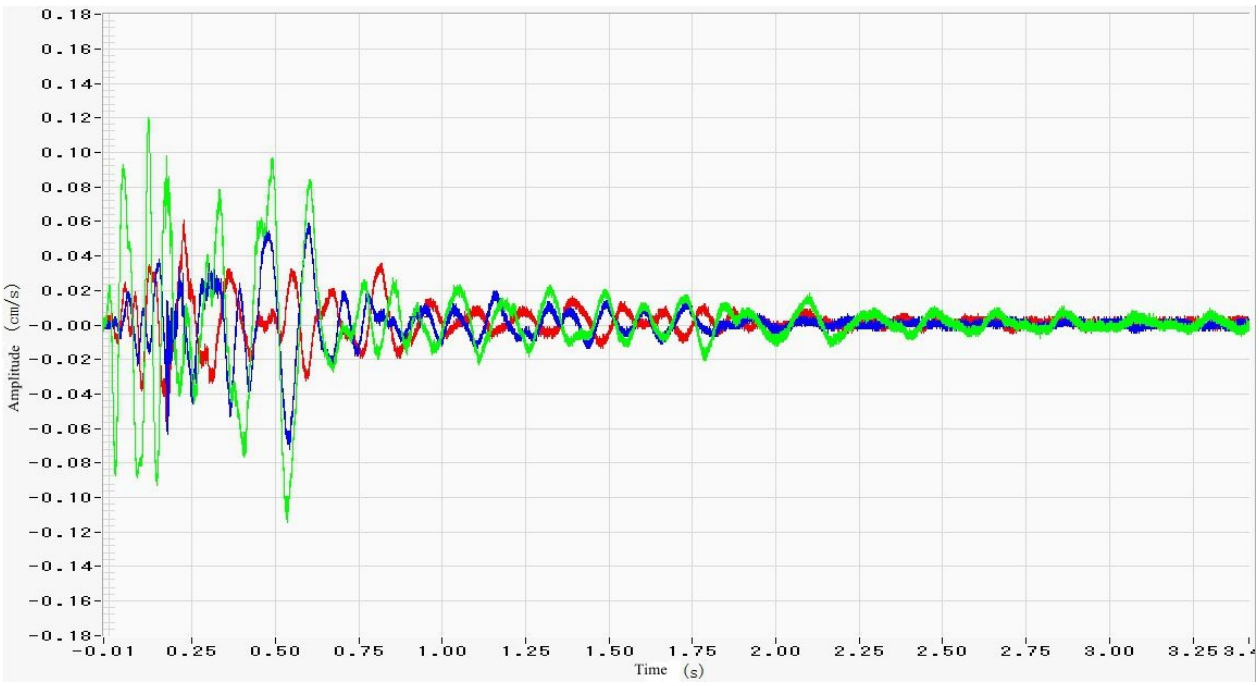



Fig.2 Measured blasting vibration wave which is 1 m distant from the right side of damping ditch

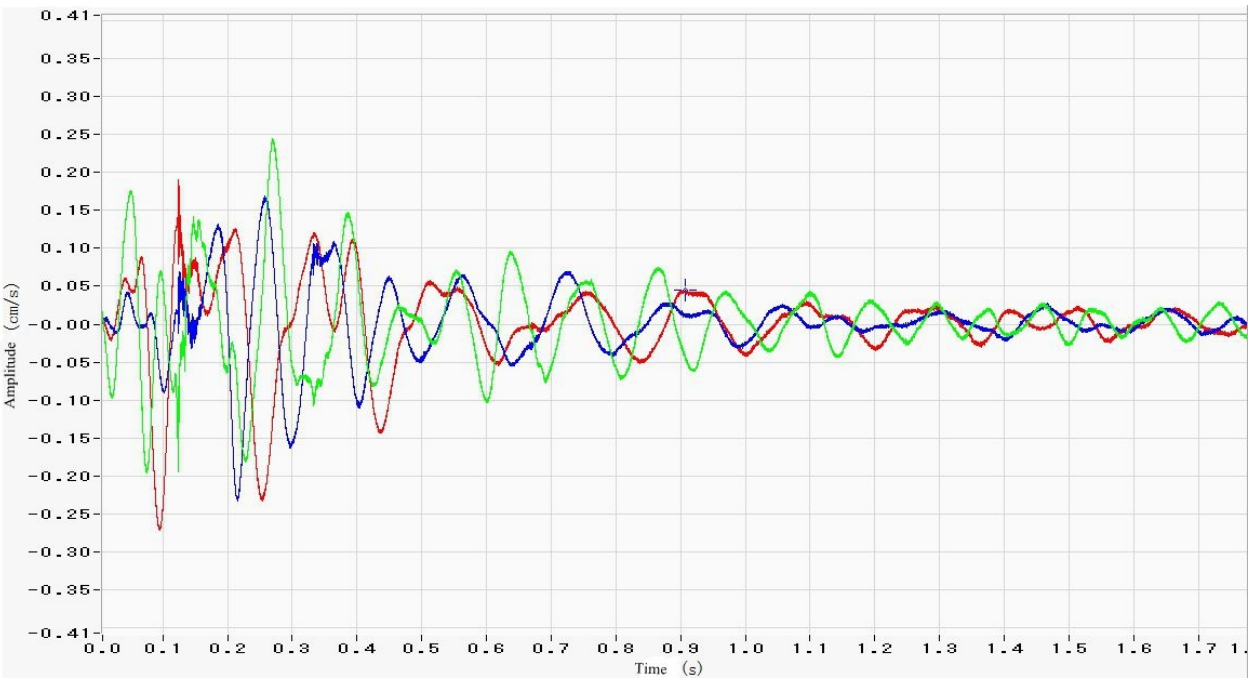



Fig.3 Measured blasting vibration wave which is 1 m distant from the left side of damping ditch

From figure 2, figure 3 and table 1 as you can see, the vibration reduction effect of damping ditch is mainly manifested in the following aspects.

(1) When the total amount of explosive, blast center distance and rock geological under the condition of basically the same, damping ditch has played a good vibration reduction effect. After blasting vibration wave bypass the damping ditch, its attenuation speed up, vibration strength reduced and duration is shortened.

(2) Comparative data in the table is visible, damping ditch in a certain area with Shock absorption effect, protected object distance damping ditch 1 to 10 m range, better effects of vibration reduction, and the closer distance damping ditch, the better the effects of vibration reduction, when something 1 m distance damping ditch, the highest vibration reduction ratio

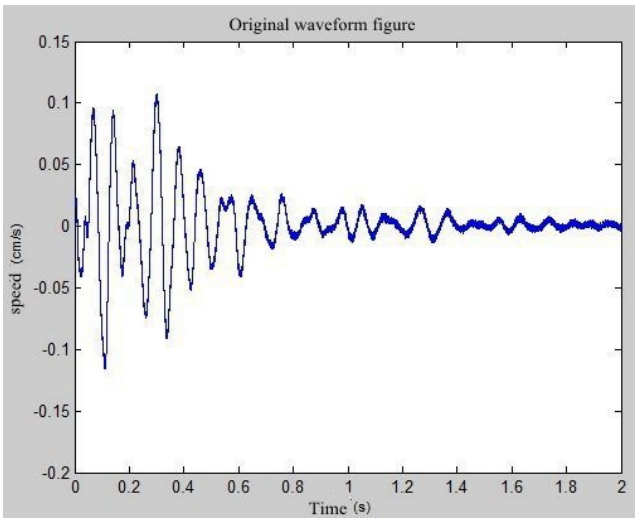
reaches 77.5%.

(3) Comparative data in the table, as you can see that after blasting vibration wave bypass the damping ditch, its horizontal radial and horizontal tangential velocity have a rebound, and the vertical peak velocity has been down.

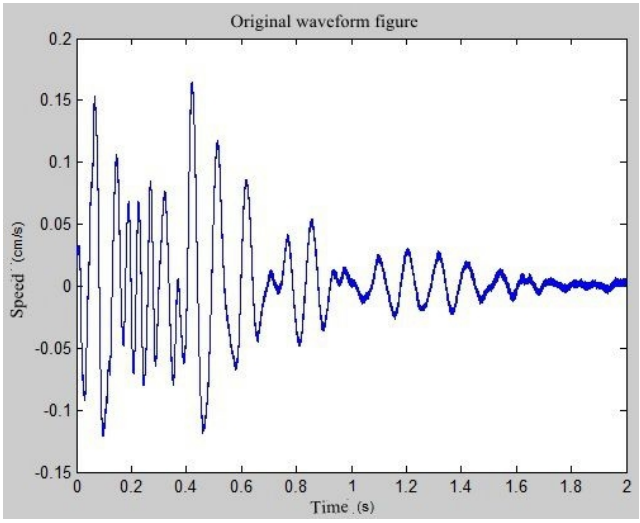
Comprehensive the above analysis shows that damping ditch does have the effect that reduce the blasting vibration, effect of decreasing vibration related to the relative position between damping ditch, protected object and explosive source. Damping ditch‘s function of decreasing vibration have some relationship with damping ditch excavation depth and depth of the hole . Horizontal radial and horizontal tangential peak vibration velocity will be a rebound after blasting vibration wave Bypass the scope of damping ditch’s function of decreasing vibration, the peak horizontal radial and horizontal tangential velocity will be a rebound, then diminishing with the increase of distance, while vertical vibration peak speed has been reduced. Thus, after blasting vibration wave bypass the damping ditch, horizontal peak velocity are the main factors of the vibration effects on the buildings, there will be a phenomenon that compared with buildings closer away from the damping ditch, those distance with damping ditch affected by the vibration is larger. Therefore, in the actual project, Should in order to facilitate the construction as the premise , according to the relative position between the damping ditch, protected objects and explosive source, Combined with the deep hole blasting parameters, dug a damping ditch for the project, to achieve the effect of vibration reduction.

**Studying damping ditch‘s impacts on main vibration frequency**

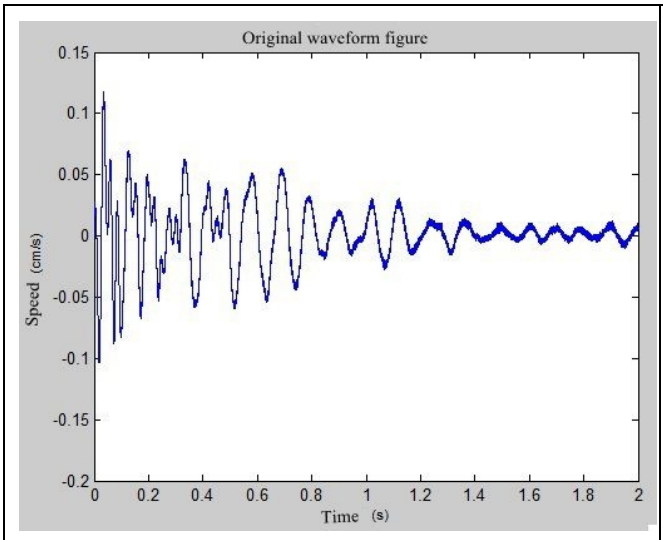
HHT method is used to analyze the band energy of blasting vibration signal in Table 1. Using the Hilbert transform the signals in table 1, we get the original waveform figure, the instantaneous energy spectrum, energy distribution. As shown in figure 4 to figure 6.



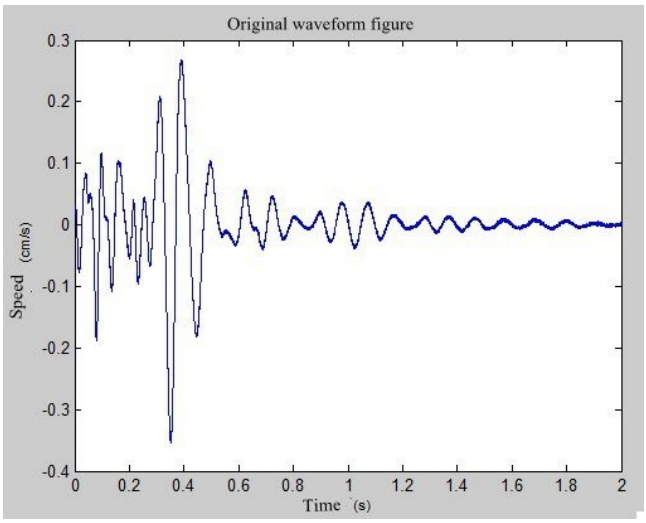

1-1




1-2




2-1

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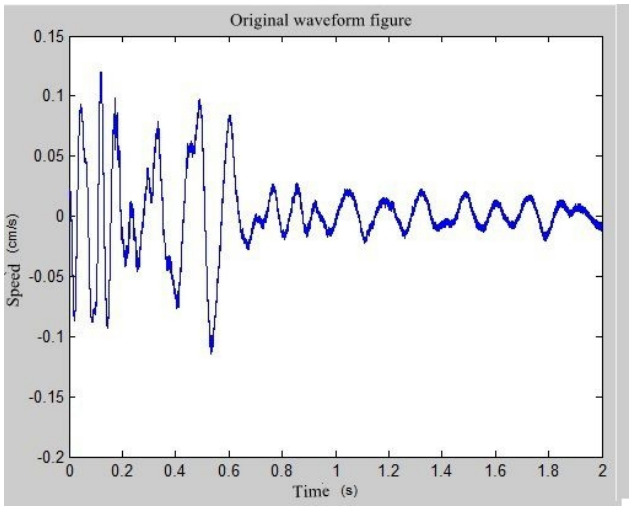
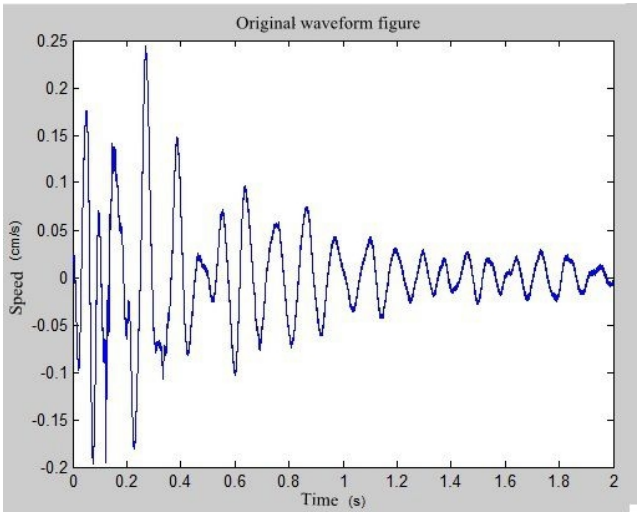
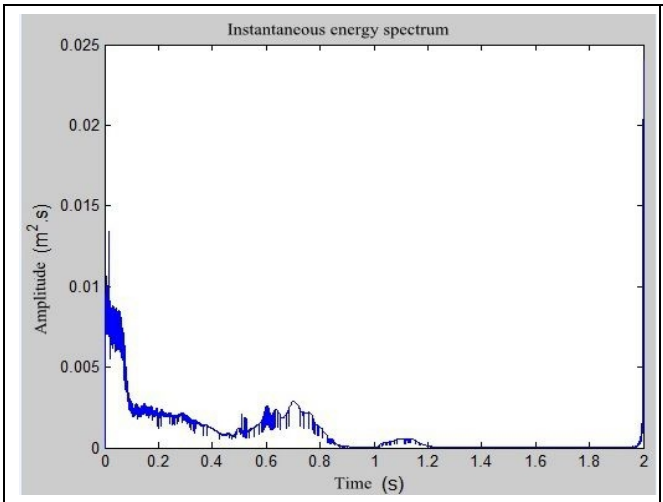



3-1




3-2

Fig.4 The original waveform figure

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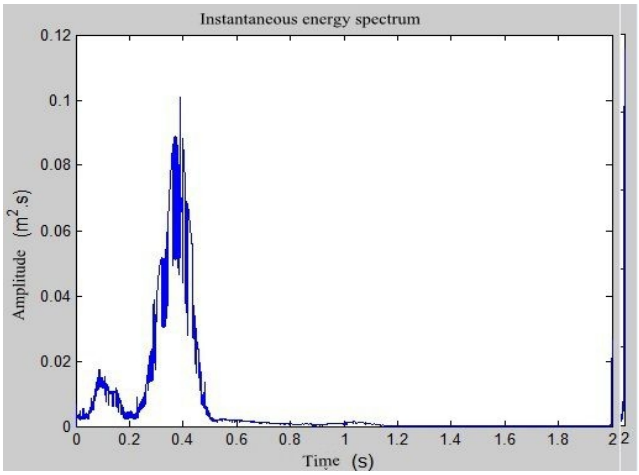


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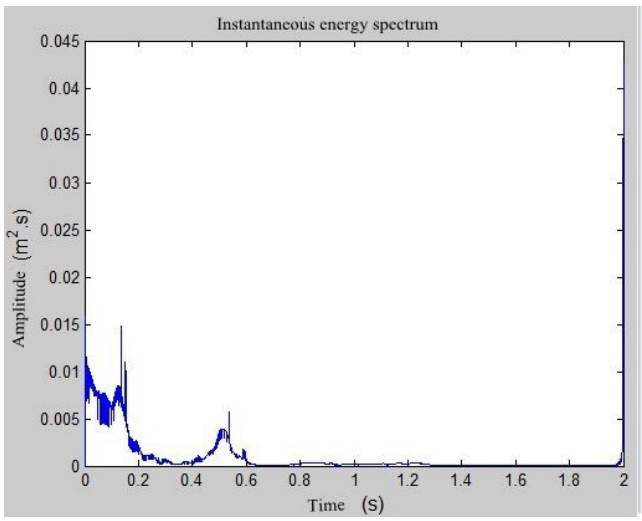


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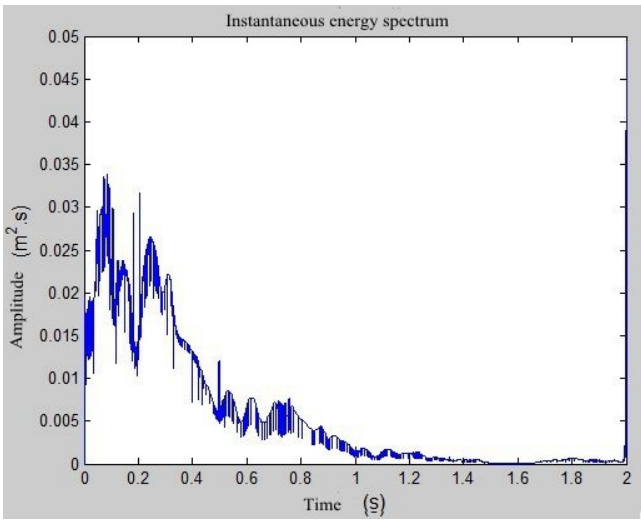


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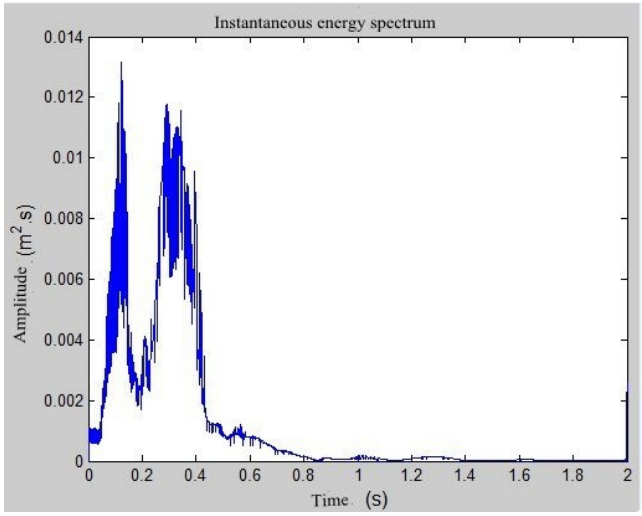


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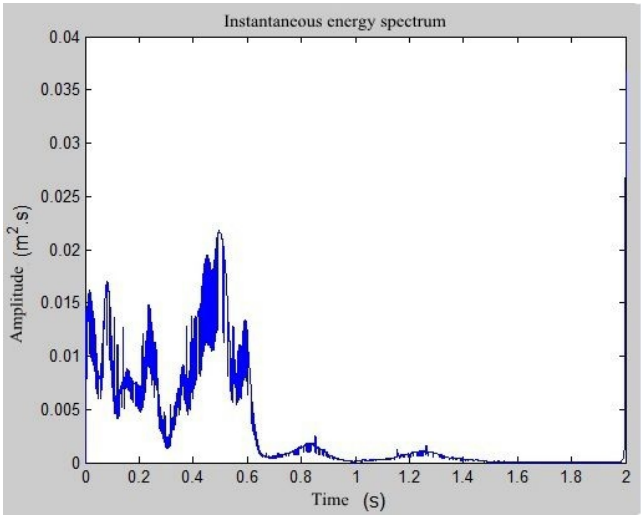
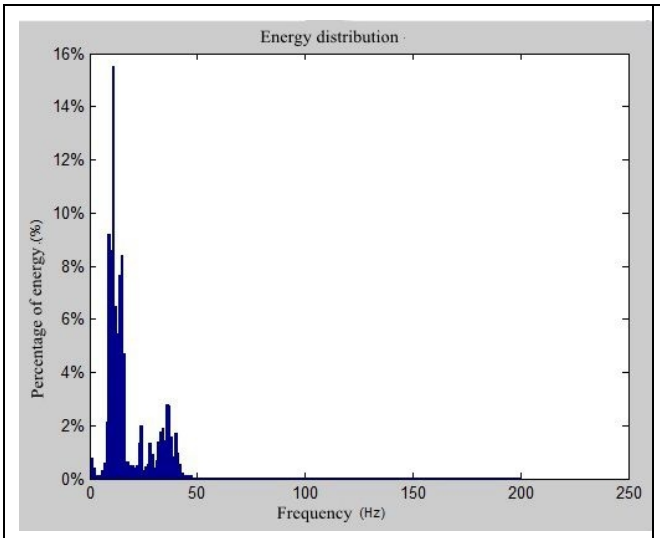
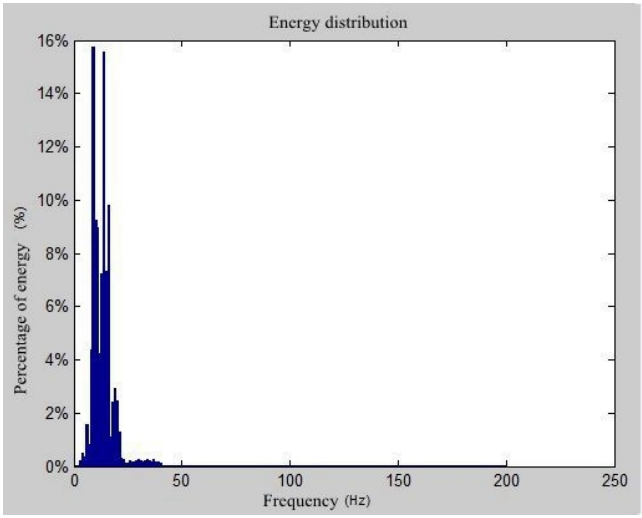



3-2

Fig.5 The instantaneous energy spectrum




1-1




1-2

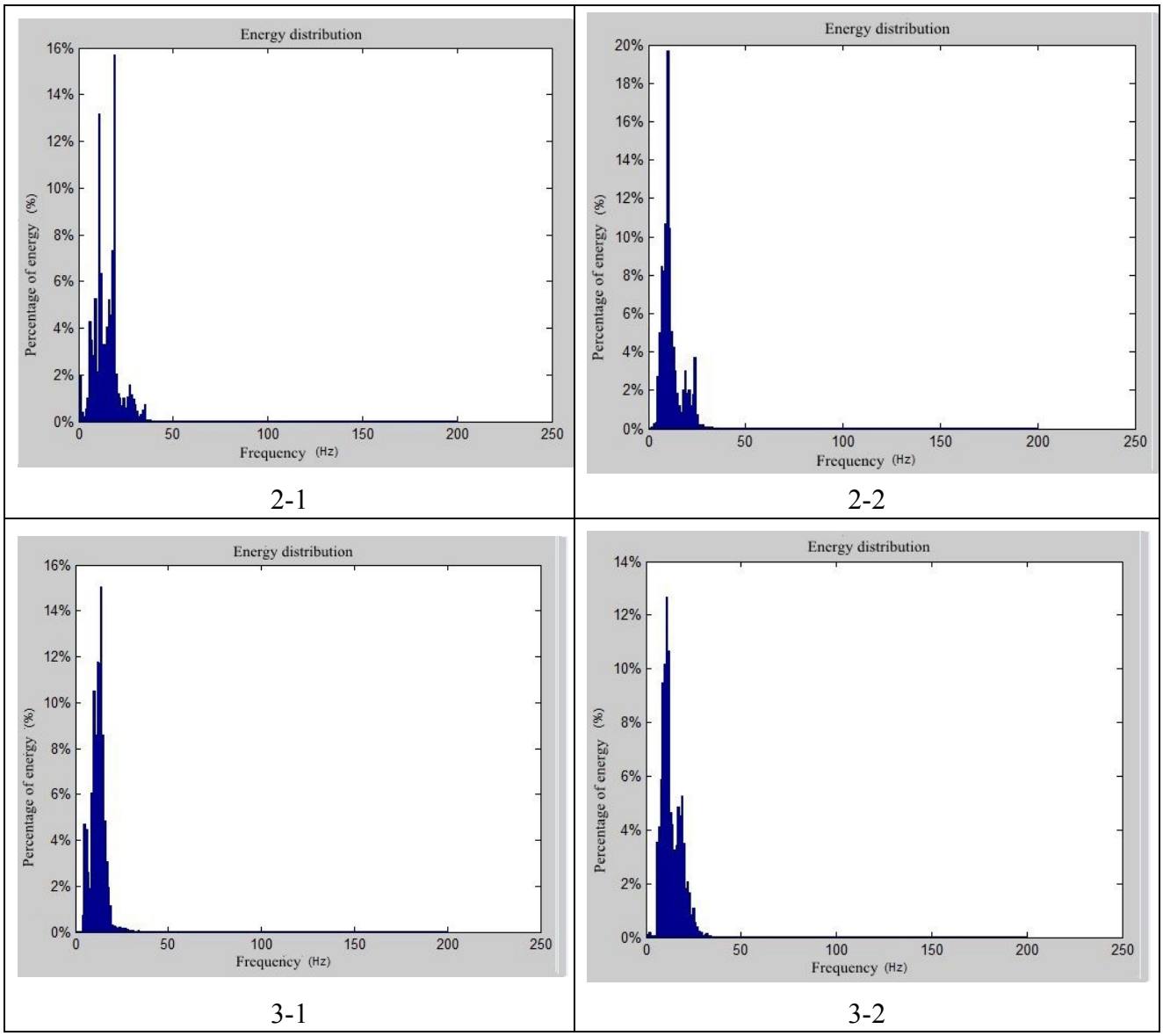



Fig.6 The energy distribution

From figure 4, figure 5 and figure 6, you can see that damping ditch on the influence of the main vibration frequency basically has the following aspects.

(1) On the right side of the damping ditch, there is a reduction in signal instantaneous energy peak, duration and instantaneous input energy.

(2) On the right side of the damping ditch 1 ~ 6 m range, the advantages of each signal frequency band energy decreases, and directed the development trend of high frequency, while on the right side of the damping ditch 10 m, the advantage of the signal to the trend of the development of the low frequency band.

Comprehensive the above analysis, after blasting vibration wave bypass the damping ditch, the instantaneous energy peak of signal is reduced, appear ahead of time, instantaneous input energy decrease which has played an important role in decreasing vibration. Distancing damping ditch in the range of 1 to 6 meters, the advantages of the frequency band energy of blasting vibration wave carrying decreases and to the high frequency of development, this is clearly in favor of the protected object security. From the peak particle vibration velocity, blasting vibration signal frequency band energy distribution, the instantaneous input energy three aspects taken into account, the range of damping ditch to reduce vibration wave effectively is 1 to 6 meters.

**Researching Damping ditch's impacts on blasting vibration wave duration**

According to literature[4, 6], blasting vibration wave duration is shorter than natural vibration wave, it generally lasts 1 to 2 s and the shortest less than 0.1 s, by adopting the method of shallow hole blasting excavation of foundation pit, the vibration wave duration is generally less than 1 s. Regions near the blasting source, its vibration wave intensity, fast attenuation and short duration; while areas far from blasting source, the opposite. This means that, the farther the distance from blasting source, the longer the duration of the blasting vibration wave is. Moreover, duration of the blasting vibration wave is mainly depends on the charging mode, detonating mode and transmission medium, under the certain condition of blasting and the blasting vibration wave duration is certain, damping ditch will have little impact on the duration of vibration waves that do not need to be considered.

## Conclusions

(1) Protected objects distance damping ditch in the range of 1 to 10 meters, the peak vibration velocity attenuation speed up, Damping ditch and the protected object distance closer, the more obvious effects of vibration reduction, When the protected object 1 m away from the damping ditch, the highest vibration reduction ratio reaches seventy-five point percent.

(2) After blasting vibration wave bypasses the damping ditch, the main vibration frequency band to carry the advantage of energy decrease, especially reserve side distance damping ditch within 1 to 6 m, wider frequency band range, directed the development trend of high frequency.

(3) From the peak particle vibration velocity, blasting vibration signal frequency band energy distribution, the instantaneous input energy three aspects taken into account, the range of damping ditch to reduce vibration wave effectively is 1 to 6 meters.

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