Comparative Experimental Study Of Blasting Vibration Signal With Different Single Section Dosage In Metro Tunnel Based On HHT Method

Xiangsheng Chen[1,a], Dehua Hu[2,b], Di Zhang[3,c*] and Sijia Wang[3]

[1]Shenzhen metro group co., LTD, Shenzhen, China

[2]The south construction investment of power construction corporation of china, Shenzhen, China

[3]School of Mechanics and Civil Engineering, China University of Mining & Technology（Beijing）, Beijing, China

[a]liq@cumtb.edu.cn [b]2237841513@126.com [c]540375465@qq.com

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Abstract: In this paper the measured blast vibration signal of tunnel between Huaxin station and Huangmugang station of Shenzhen subway line 7 was analyzed, with blasting excavation way of benching tunneling construction method using different maximum charge of explosives. The peak vibration velocity and main frequency after explosion using different single section dose was comparative analyzed. The results demonstrate that: section dose increasing from 2.4kg to 3.6kg makes blasting vibration velocity bigger and main frequency lower. Meanwhile, the change of energy distribution curve at different frequency after blasting with two section dose based on HHT analyze methods was comparative analyzed. The research indicates that: the input energy through blasting vibration at low frequency (0-20Hz) becomes significantly larger, however the input energy ratio at middle and high frequency sharply decreased as section dose increased. In real construction, improving cyclical footage by increasing section dose should be used careful. A new way to control blasting vibration was proposed through the research.

In recent years, many big cities have built subway. Because of the buried depth is 20-30m, when there is hard rock, the drilling and blasting methods was used. The influence of blasting load on adjacent structures and buildings always the focus of the research when excavation in busy city district[1,2]. The previous study indicates that: the main factors that effect blasting vibration were blasting dose, main frequency and delay time. Maximum blasting dose was most important factor. How to decrease building disturbance of blasting vibration, improve cyclical footage , ensure good blasting effect are difficulty and emphasis of blasting construction[3,4].

Hilbert-Huang Transform is main method to analyze blasting vibration signal. It is made up of EMD (Empirical Mode Decomposition)and Hilbert transform. Signal is decomposed into many Intrinsic Mode Function factor by EMD. The instantaneous frequency of every component is obtained by using Hilbert transform to every IMF component. Hilbert spectrum is obtained by integrate with every instantaneous frequency[5].The HilbertHuang Marginal Spectrum, instantaneous energy and three dimensional spectrum can be obtained by integral transform to Hilbert spectrum. It is used to analyze frequency of blasting vibration signal, delay time and energy distribution conditions.

In this paper, the influence of blasting excavation on controlling safety of tunnel was comparative analyzed by combining with field experiments and energy analysis using HHT

transform of blasting vibration signal based on tunnel blasting excavation between Huaxin station and Huangmugang station of Shenzhen subway line 7. A new method to control blasting vibration was provided.

Engineering situation

Running tunnel between Huaxin station and Huangmugang station are excavated with width of 6.8m and height of 6.8m，and the area are about 40m^2. The benching tunneling construction method are used and the excavation cyclical footage is 1.0m. There are 8 period numbers as 1、3、5、7、9、11、13、15 used in detonators. Explosive consumption is about 1kg/m^3. The biggest single section dosage of upper bench is 3.6kg，the shape of cutting hole is double wedge and the distance of periphery hole is 400mm while the under bench is 2.4kg and 500mm. Millisecond subsection blasting technology out of holes are used if the vibration velocity is over standard，there are used 1、3 and 5 subsections to control blasting，which can reduce the single section dosage once again.

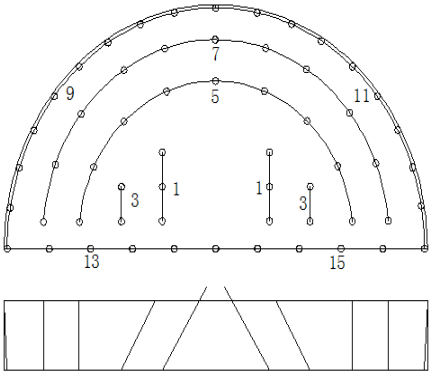


Fig1 Picture of upper benchblast-hole arrangement

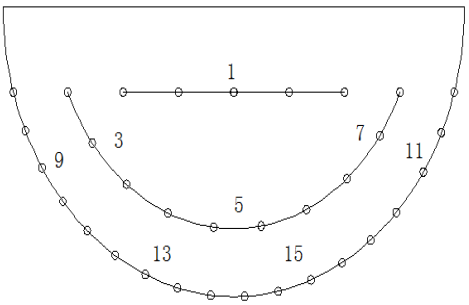
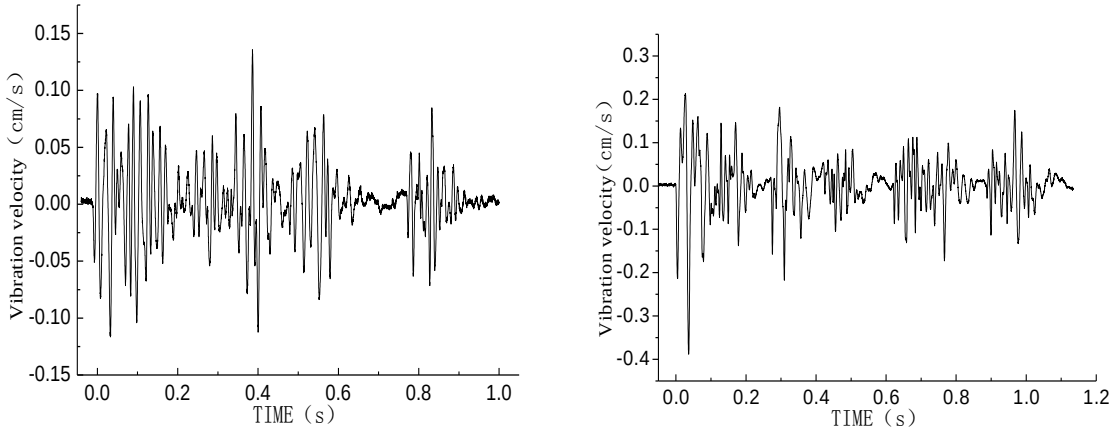


Fig2 Picture of under benchblast-hole arrangement

Relationship between the maximal segment charge and the main frequency

The speed oscillogram of Blasting Vibration of whose single segment charge are 2.4kg and 3.6kg is shown in Fig.3, and the main frequency change curve of Blasting Vibration under two maximum segment charge is shown in Fig.4. In Fig.3, the blasting vibration velocity peak value will have a sharp growth if the maximum segment charge increases, the blasting vibration velocity peak value is 0.14cm/s under 2.4kg segment charge, and it reaches 0.38cm/s under 3.6kg segment charge.

The main frequency presents concussion changes with the increase of the distance under two segment charges, and the greater the distance, the main frequency had a trend to the lower value. At the same time, the blasting main frequency of 3.6kg segment charge is much smaller that of 2.4kg segment charge obviously in the above figure. Under 2.4kg segment charge, the mean blasting main frequency is 52Hz, which decreases to 30Hz where the distance is close to 40m.While under 3.6kg segment charge, the mean blasting main frequency is 36Hz, which decreases to 11Hz even where the distance is close to 42m. Therefore, increasing maximum segment charge will make the blasting vibration velocity value greater, and decrease the blasting main frequency. So safety control of blasting must be taken in other measures （such as increase hole external segmentation, free face and so on），when segment charge is increased in the design of blasting parameters.



(a) section dosage 2.4kg (b) section dosage 3.6kg

Fig.3 Picture of Blasting vibration velocity in benching tunneling construction

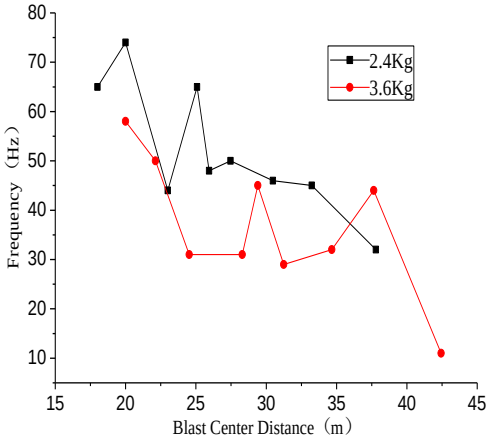
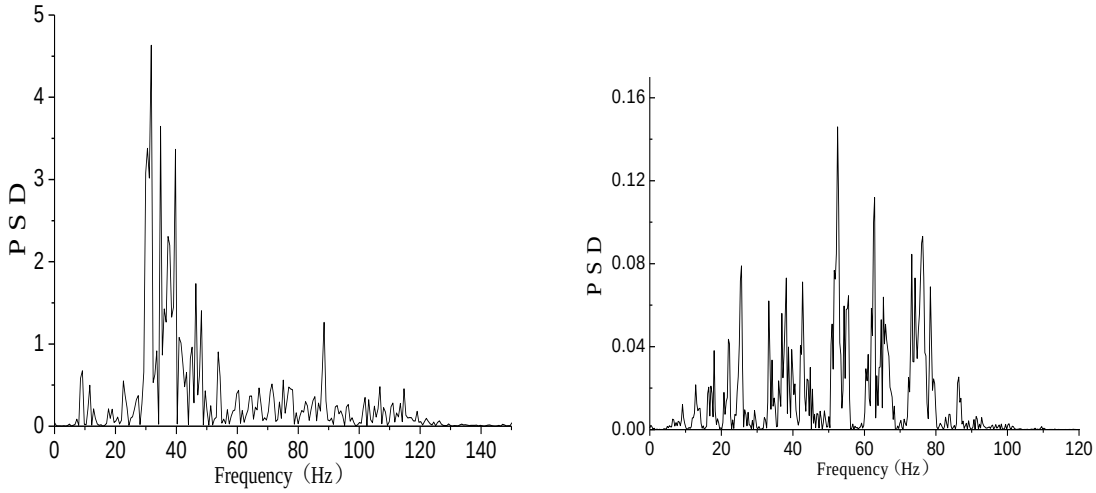


Fig.4 Change curve of the main frequency with different single section dosage

The whole main frequency which can be summarized obviously in the above figures is between 20—70Hz in subway blasting excavations. Of which, lower than 15Hz ultra-low frequency or more than 100 Hz main frequency is few, the frequency of the main frequency which is lower than 20Hz the distance is more than 35m far from the explosion center, so building disturbance far from the explosion center more than 35m should be main monitoring under the actual process of blasting. The High Frequency part attenuation is very fast, while the Low Frequency is very relatively slow. The main vibrating frequency of the signals has a downward trend with the increase of distance, but the trend is not strict attenuation with the increase of blast center distance, which will take on mutation or fluctuation in part with the increase of propagation distance. Therefore, there are great limitations only based on field monitoring results, further theoretical analysis should be taken.

Marginal spectrum of singal

Known from the vibration theory analysis: complex vibration signal is the superposition of harmonic component of different frequency. One or more resonant frequency is the main frequency components , corresponding frequency is called main frequency. Blasting vibration wave including abundant harmonic frequency ,has some bandwidth. According to the different bandwidth of signal spectrum, it can be divided into “narrow spectrum ”and “broadband spectrum”, as shown in the Fig.5. The main frequency energy of narrow spectrum is large and the harmonic components energy is small. The main frequency is main evaluation of frequency characteristic of blasting vibration. The characteristics of broadband spectrum is that the main frequency energy is not herniation and the sum of energy of each harmonic frequency is larger.



(a) narrow spectrum (b) broadband spectrum

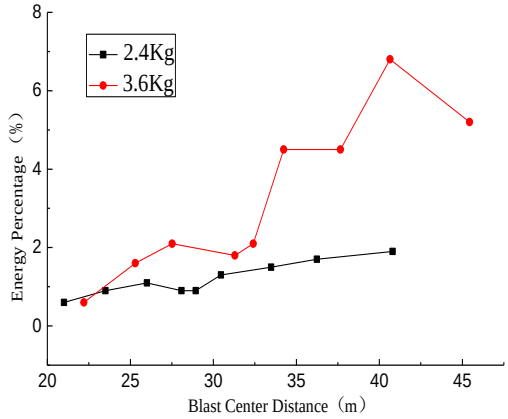
Fig5 typical narrow spectrum and broadband spectrum

Seen from Fig.5, the main frequency of the two signal spectrums are more than 30Hz, according to previous evaluation standard, the two blasting are security. But by marginal spectrum of the two singals, the energy of main band range of narrow marginal spectrum is very large, the energy of the others is very small, the instantaneous input of energy in main frequency band will probably be more than the limit lastic variables of buildings and cause of damages to buildings. And the distribution of energy in 40—150Hz safety range of broadband marginal spectrum is very uniform, multi-peak structure has appeared, energy is more dispersion, the energy between maximum and minimum is more than 2 times. and the energy percentage in 0—20Hz of "risk" band is relatively small. Comparatively speaking the degradation of energy will decrease the effect on buildings. Broadband spectrum provide a new way to decrease the effect of blasting vibration.So the description of frequency characteristic of blasting vibration wave and destructive effect to buildings or structures of blasting vibration only with main frequency is not very overall. According to the characteristics of frequency domain wave, method of combining main frequency ,main frequency band and marginal spectrum should be adopted to make a comprehensive analysis of the spectrum characteristics of blasting vibration wave.The frequency characteristics of blasting vibration can be reflected overall. The main frequency band refers to frequencies intervals composed of the energy of harmonic frequency reaching to a certain numerical(generally 70 percent of energy of main frequency).

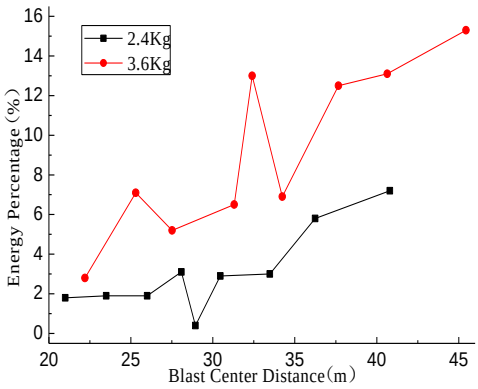
Relationship between the most explosive charge and frequency band energy

Figure 6(a) is the frequency band of 0-10 Hz energy accounted for the proportion of the total energy changes with the increase of the distance. Can see from the picture, with the increase of distance, two doses in 0-10 Hz has a different degree of growth as a percentage of the energy of the period of the dosage of 2.4kg after blasting energy within 0-10 Hz with the increase of the distance from the growth of small, at the same time the overall percentage of energy also very little, from 41 m in an explosive source is close to 2%, the percentage of energy due to 0-10 Hz frequency range of buildings can cause resonance, so when the most explosive blasting is 2.4kg, and the actual measurement shows blasting control within the scope of security; Then when the dosage of 3.6kg, the percentage of energy along with the increase of the distance is larger, the maximum has reached 7%. From (b) you can see at the same time, within the scope of the 10-20 Hz, two of the most explosive under the percentage of energy also increases with the increase of distance, and the most explosive charge of 3.6kg of growth than the dosage of 2.4kg. To produce energy during the

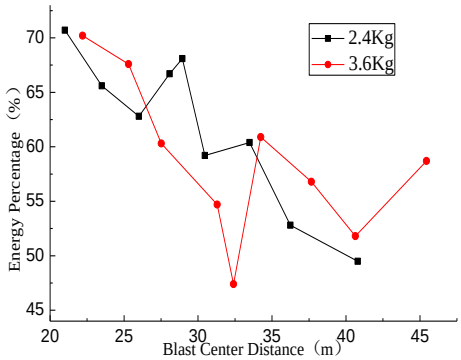
process of blasting vibration wave propagation attenuation, the different frequency of the energy attenuation, however, the energy attenuation of high frequency components than the low frequency part, and the frequency zone of low frequency part of the frequency decrease rate is lower than the high frequency part of the lower rate. As the most explosive increase of the blasting vibration of low frequency part (0-20 Hz) growth rate also will increase, the increase of the amplitude is also very obvious, so in the actual construction process to increase blasting footage, also carefully consider increase the explosive way.



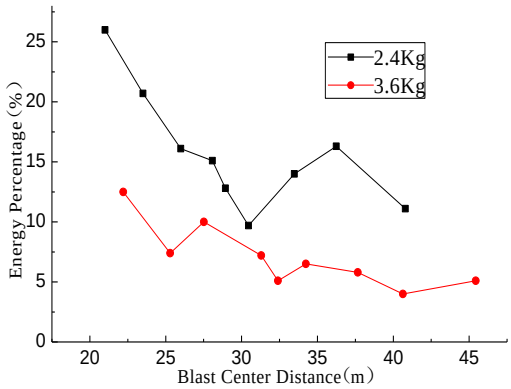
（a）0—10Hz



(b)10—20Hz



(c) 20—70Hz



(d) 70—100Hz

Fig.6 Change curve of the frequency band energy with distance increasing under two kinds of section dosages

Fig.6(c) is the energy´s distribution band of blasting vibration. From graph (c) we can see, the proportion of energy´s band range is from 20hz to 70Hz is very high. When it is 20 meters away from explosion source, the proportion of two kind of maximal section explosive load weight is amazingly up to 70%.With the increase of its distance, energy´s proportion under two kind of circumstance all start to reduce, but the average energy´s proportion all are over 50%. Under the circumstance of blast-shaking speed accords with standard, it is an ideal blasting effect.Under the circumstance of do not consider effect of band over 100%, 70Hz—100Hz of Fig.(d) is the highest frequency band of blasting vibration. Under two blasting´s circumstance, with the increase of blast center distance,the energy proportion all have different degree descend.ultimately,41 meters away from explosion source,the energy proportion of segment explosive quantityof 2.4kg and 3.6kg is partly 12% and 6%.

From above four Graphs we can see, the signal´s energy shows the characteristic of hill feature that middle is bigger than both ends. With the increase of distance, the part mountain peak move gradually torwards the direction of low frequency. Because what the studying team monitor is the

circumstance of ascending and descending stairs,under the circumstance of descending stairs´s maximal section explosive load weight is less than ascending, having large free face is a more important reason which makes blasting main frequency high and energy´s proportion of low frequency less.

Conclusion

This text combine with actual engineering of blasting excavation huahuang running tunnel of shenzhen subway line 7,by the method of field test and theoretical research,we arrival at some conclusions and laws, as follows:

(1)Single segment dosage increase from 2.4kg to 3.6kg,which not only raise the speed of blasting vibration，but also lower the main frequency. In the early phase, when we make the design of blasting parameters,if improving maximal section explosive load weight,we must take other steps to make safety sure.

(2)The whole blasting frequency of subway blasting excavation is between 20 to 70Hz, signals blasting frequency shows trend of descend with the improving of distance. But it is not severely showing the trend of descend with the raise of blast center distance,and also do not make local mutation and fluctuation happened with the raise of propagation distance.

(3)With the raise of segment explosive quantity,at the low frequency part, blasting vibration input energy clearly become bigger, by contrary, the energy proportion of other parts have clearly descend. In the progress of actual engineering, we have to be cautious to take method of improving segment explosive quantity to rise advance per round.

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