STUDY ON THE BLASTING SEISMIC DAMAGE CONTROL TECHNOLOGY FOR SMALL SPACING SOFT ROCK TUNNEL

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ABSTRACT

With a lot construction of transportation infrastructure in Chinese mountainous area, because of its unique advantages such as less land occupation, beautiful appearance and convenient route planning, small spacing tunnels are widely used. The shallow buried tunnel with small spacing, the blasting excavation will lead to tunnel surrounding rock especially in the middle rock wall damage and reduce the self-bearing capacity of surrounding rock. Through detecting and analyzing by the geological radar of the excavated red layer soft rock tunnel surrounding rock found that the middle rock wall loose circle thickness of the tunnel reaches to 1.8 m, the vault and sidewall loose circle thickness is about 1.2 m. Through selection of rational strengthening measures and blasting design scheme to improve drilling parameters and methods, as far as possible to protect the integrity and self-bearing capacity of the surrounding rock, the deformation and vibration of the tunnel would be controlled in reasonable limits and ensure the safety of tunnel construction.

KEYWORDS

Small spacing tunnel, Red layer soft surrounding rock, Blasting damage, optimization, Grouting reinforcement.

INTRODUCTION

The small spacing tunnel is a new type of tunnel structure, which is between the ordinary separated tunnel and multi arch tunnel [1]. As one of the important forms of tunnel structure, it has the advantages that the line selection is not restricted by terrain, occupies little land, and has a protective effect on ecological environment. Compared with multi arch tunnel, small spacing tunnel also has a simple construction technology, is easy on waterproof treatment and easy to control, easy on cost control. All these features are not available in the separated tunnel. As a result, small spacing tunnels have been widely used in highway [2], railway [3] and urban subway [4,5]. Even in the railway double track reform and express highway extension process, due to the presence of the original tunnel, the expansion project needs to construct the new tunnel near the original tunnel, which causes the small clear distance tunnel group appearance [6, 7]. For example, in China, Qingshan tunnel and Yangliuwang tunnel of Neijia ng-Kunming railway, Xinpingqu tunnel,Xinpingkou tunnel and Xinliutan tunnel of Hunan-Guizhou double track reform railway, Xujiahe tunnel of Baoji-Chengdu double track reform railway. In the highway tunnel and urban tunnel, the Dujiangyan-Wenchuan expressway Zipingpu tunnel, Beijing-Fuzhou expressway Jin Shan tunnel, Beijing Fuzhou National Highway Liyang Tunnel,and Quanzhou City Fengze Street tunnel,Jinggangshan City Shishi tunnel and Ningbo Zhaobaoshan tunnel,as well as Japan Ogitsu highway tunnel and Italy LocooColio highway tunnel. It is just because of the particularity and practicality of the structure of the small spacing tunnel, it has gradually become one of the effective types under special geological conditions for the convergence of highway line, bridge and tunnel, general linear optimization and rational use of land resources and other issues. With the gradual enhancement of ecological awareness in highway and railway construction, increasingly valuable land resources, it is foreseeable that, in the future, mountain highways, railways and urban subway project construction, small clear distance tunnel will play a more important role.

As for the construction method, the cost and benefit of the tunnel excavation can be realized by the blasting method [8].Therefore, at present, the drilling and blasting method is still the main method of tunnel construction in mountain area [9]. However, due to the spacing distance of small spacing tunnel spacing is relatively small, the construction process is complex, especially in the drilling and blasting method, disturbance of surrounding rock around the tunnel is large, the circumferential stress will increase instantly, generate new random crack, thus affecting the stability of surrounding rock and the permeability. When it is serious, it will lead to the whole instability and even destruction of the tunnel [10, 11]. For the bias and soft rock small spacing tunnel, the harm caused by blasting will be more prominent [12, 13]. At the same time, the blasting of the left hole and right hole will cause mutual interference. This interference can cause stress superposition, even stress concentration. In this case, the plastic zone and deformation of the surrounding rock will be further expanded. Once the strength of the surrounding rock is exceeded, the surrounding rock will be destroyed, which will have an important impact on the safety of the project [14, 15].The worse the surrounding rock conditions, the smaller the thickness of the rock column, the greater the difficulty of the construction, the longer the construction period, the greater the impact on the whole line. Therefore, on the blasting damage and control technology of the small spacing tunnel with different surrounding rock conditions, many scholars at home and abroad have carried out the theoretical research [16,17], experimental study [18, 19], field monitoring analysis, as well as control technology of blasting vibration damage [20, 21] and have made a lot of achievements. However, due to the complexity and uncertainty of the geological conditions of the tunnel, the control and reinforcement technology of the blasting damage of small spacing tunnel is still a difficult problem.

Therefore, this paper, combined with the engineering practice, through the analysis of blasting wave propagation principle and the characteristics of blasting seismic damage and the field test of blasting optimization, the control technology of blasting damage of the supporting engineering small spacing tunnel is proposed.

INFLUENCE OF BLASTING ON TUNNEL STRUCTURE DAMAGE

Characteristics of blasting seismic wave

Due to the complexity of blasting, the diversity of physical and mechanical parameters of the medium and the diversity of the geological structure, the blasting seismic wave has the characteristics of randomness and non-repetition, so the blasting seismic wave is regarded as a random wave. The blasting seismic wave not only behaves as miscellaneous changes with the time in amplitude, and the vibration frequency and duration of the wave exhibit extremely complex phenomenon with the effect of environmental conditions, blasting type, core distance and strata.

The blasting frequency reflects the rate of blasting seismic wave and the frequency of high frequency wave changes rapidly. Blasting seismic wave contains 0 ~ ∞Hz all frequency components. The blasting seismic wave frequency spectrum is a continuous spectrum, not discrete frequency components. Through resonance theory, we can see that a wave of a specific frequency causes an increase in the vibration of the natural frequency structure. In the process of vibration analysis, the structure usually contains structure with a variety of different natural frequencies and its substructure, especially the low-frequency part of the wave is not to be ignored. However, we should not only pay attention to the low frequency waves, but also ignore the high frequency waves.

Sometimes high frequency waves play a very important role in the process of structural vibration analysis. The process of blasting seismic wave energy release is usually shorter, and has the characteristics of sudden transient vibration. In different rock mass medium, the energy consumed in the seismic zone is different, the main reason is that the media depends on the characteristics of the propagation; the energy of the area is only about 3%-20% of the total energy.

Harm of blasting seismic wave

The existence of weak structures such as faults and joints in the strata or strata of the tunnel affects and weakens the strength characteristics of rock and soil. When the blasting seismic wave gives the weak surface an Instantaneous dynamic load moment, and its vibration intensity reaches a certain standard, the tunnel structure first causes damage at the weak surface. There is a large number of randomly distributed micro cracks in the surrounding rock of the tunnel and the concrete. In accordance with the Griffith theory, the moment of blasting seismic wave, it generated great stress concentration at the crack tip, and when tensile stress reaches the tensile strength, micro cracks will form more. Because of the existence of the looseness of the medium and the structural plane, the tunnel absorbs most of the energy in the process of blasting seismic wave propagation， which induce structural vibration. The loose medium and the structure surface are relatively weak in the condition of not being destroyed by the macroscopic damage, and have some looseness compared with the initial state. This may eventually lead to tunnel damage.

Analysis of influence factors of blasting on tunnel structure damage

Because of the randomness of the blasting seismic wave, the richness of the frequency, the concealment and the variability, blasting is a very complicated process. Long-term blasting engineering practice and experimental results show that the main factors affecting the blasting seismic wave are mainly as follows:

Influence of rock mass on blasting seismic wave. The maximum amplitude of the medium with more density and rigid brittle is smaller than that of loose medium. In the rigid medium, compression wave attenuation is smaller. There is no obvious difference in the attenuation of surface waves in various media. The wave amplitude of rigid medium compression wave and Rayleigh wave is usually larger than that in soft medium. The harder the rock medium is, the higher the frequency of blasting seismic wave is.

Influence of blasting type on seismic wave. Blasting can be divided into two kinds of instantaneous blasting and delayed blasting. Under the condition of the same amount of explosive charge, the difference between the two is that the former has strong amplitude, but the number of vibration is less. When evaluating the vibration effect of blasting on structure, it is necessary to pay attention to the influence of the two factors of vibration intensity and vibration duration.

Influence of blasting charge on seismic wave. Blasting charge is one of the most basic factors that affect the intensity and range of blasting disturbance. Under the condition of a certain amount of charge, the blasting vibration velocity decreases with the increase of distance, and the decrease, speed is related to the attenuation coefficient of rock.

Influence of coupling characteristics of blasting charge on seismic wave. Blasting and rock coupling medicine includes geometry coupling and impedance coupling. The results show that the dynamic strain of rock is proportional to the 1.5 power. It is known that the dynamic strain of the rock with complete geometric coupling (100%) is the largest, and the same as the characteristic impedance of rock and explosive, the dynamic strain of rock is the largest.

The influence of topography on seismic wave. In the soft soil layer, the amplitude of the high frequency seismic wave is small, and the amplitude of low frequency is larger. In the hard rock, the amplitude of low frequency seismic wave is small and the amplitude of high frequency is larger. Hard rock and soil wave propagation speed, soft soil was relatively slow dissemination. The thickness of the covering soil layer also has a significant effect on the frequency of the wave propagating in the soil layer.

Damage control technique of tunnel blasting

Tunnel blasting will inevitably cause damage to tunnel surrounding rock and support structure. The stress of the rock column in the small spacing tunnel is complicated; the conversion of the force form of the structure is more. For reducing the blasting damage in dyke and rock self-bearing force, it plays a very important role. Control of tunnel blasting damage can be divided into two aspects, one is the active control technology based on the blasting scheme and parameter design, and another is before or after the surrounding rock damages the passive reinforcement measures. Generally, the comprehensive utilization of the two methods is more conducive to the protection of surrounding rock and achieves economic security effect in tunnel construction. It mainly reflected in the following aspects.

Millisecond blasting. In the millisecond blasting, compared with simultaneous blasting, earthquake can be reduced about 50%.The more the number of differential segments, the better the effect of vibration reduction. According to the experience of blasting engineering, when the interval between blasting and blasting is greater than or equal to 50ms, there will be no superposition of vibration waveform.

Maximum charge of control section. The maximum charge of the control section is to control the scale of explosive release energy. Under the objective condition that the geological condition and structure cannot be changed randomly; the maximum charge of the control section can significantly reduce the vibration effect and achieve the purpose of controlling the blasting vibration velocity. The maximum dosage of the control section must be combined with the millisecond blasting method to maximize the effect.

Add free surface. To increase the free surface of excavation, on the one hand, it can play the role of partial blasting and reduce the maximum vibration effect. On the other hand, it is more important to reduce the effect of surrounding strata on the excavation of rock and soil, to reduce the dosage to achieve the effect of vibration reduction.

Pre-splitting blasting. Though the fracture which generated by the pre-crack blasting cuts off the vibration wave propagation, which play the effect to reduce the blasting vibration.

Adjustment of peripheral explosive holes layout. In the peripheral blasting holes of the excavation section, dense drilling hole, interval charge (the middle of the two charge of the hole is not loaded, empty hole, main slit guidance function), can significantly reduce the blasting vibration.

THE ACTUAL ENGINEERING PROJECT SURVEY

Engineering geological conditions and deformation

The tunnel is a small spacing tunnel designed according to the standard of first class highway four lanes in two directions. The minimum distance between the left and right holes is less than 14m. The starting and stopping pile number of the tunnel left hole is BZK0+687~ BZK1+165, long 478m. Maximum buried depth 50m. The starting and stopping pile number of the tunnel right hole is BYK0+680～BYK1+150, long 470m. Maximum buried depth 51m. The buried depth less than 30m accounted for about 70% of the total length. This tunnel has complex geological conditions with low intensity of the surrounding rock, which is all IV and V grade laminated argillaceous limestone.

With three residents living on the ground of the tunnel and a dozen residents near the exit of the hole, if the control of blasting is improper, as may endanger life and property safety of these residents and lead to tensions relationship between local residents and the constructor.

The stress in the dykes of shallow buried small spacing tunnel is in plastic state and less ground cover, while blasting excavated, improper handling can easily lead to instability in dike and vault landslides and other disasters. Non-serious disaster will cause property loss and delay of construction period, serious disaster will cause construction accidents. Therefore, the tunnel construction put forward a high demand in the control of blasting vibration. Tunnel excavation begins at the exit section. The surrounding rock of the right hole is basically consistent with the prediction of the survey data. According to the design plan, construction progress is without incident. The surrounding rock of the exit of the left tunnel is poor, and the water content is much. After the excavation, the surrounding convergence and vault settlement are larger, and the problem is solved by grouting and strong support. However, when the tunnel is excavated near BZK0+830, the surrounding rock becomes thin, low strength and large water content. Geological conditions are different from the survey data. After excavation, the vault settlement and surrounding convergence increased rapidly. The design has been unable to meet the normal construction of the tunnel. Therefore, it is necessary to use reasonable seismic control technology and reinforcement measures to ensure the safety and quality of tunnel construction.

Blasting scheme of design and optimization

In order to reduce the harm of blasting vibration and improve the effect of excavation, the following measures are adopted in construction：

① When determining tunnel excavation and cyclic footage, by blasting test，the blasting vibration is controlled within the allowable range to ensure the safety of the tunnel support structure and the surface structure, and minimize the interference to the residents' life

② According to the geological conditions, excavation section, excavation cyclic footage, blasting equipment and vibration velocity requirements design blasting excavation scheme

③ According to the characteristics of surrounding rock, reasonably choice peripheral hole distance and the minimum resistance line. Arrange the peripheral holes and auxiliary holes on the same vertical plane

④ According to the blasting safety regulations and tests, strictly controlled the blasting vibration velocity

⑤ The detonator selects the millisecond detonator, each interval is larger than 50ms, avoiding the superposition of seismic waves, and reducing the vibration

⑥ Strictly control the charge of peripheral holes, Interval charge with the help of detonating cord, uniformly distributed the charge along the holes, ensure that the tunnel surrounding well formed, and reduce the disturbance to the surrounding rock

⑦ According to the drilling and blasting effect, adjust the form of the cut hole and blasting parameters and deepen the depth of the holes to ensure the effectiveness of the cut hole

⑧ According to the structural safety requirements, the ability to cycle construction, different levels of surrounding rock, consider synthetically footage driving cycle

⑨ The maximum charge quantity is determined by the comprehensive geological conditions and the characteristics of explosives.

In order to provide sufficient free surface for the auxiliary hole and the surrounding hole, the blast hole will be deeper 15 ~ 25cm than that of the auxiliary hole and the surrounding hole, and explosive dosage will be more. When the explosive in the cut hole is only one free surface in the explosion, about 15% of the explosive energy is transmitted to the surrounding rock in the form of seismic waves destroying the original structure and state of surrounding rock and reducing the self-bearing capacity of surrounding rock. The optimum design of blasting scheme depends on the optimization design of cut hole. The commonly used optimization design of blasting is non-coupling charge, multi segment millisecond blasting, and pre splitting blasting and so on. The tunnel face surrounding rock structure is approximate thin level with horizontal angle only about 15 degrees. The use of pre splitting blasting will be damaged the rock several meters below blasting hole. Therefore, pre-splitting blasting is not suitable for the tunnel. BZK0+830 is the rock surrounding rock, the design of support type XS5 (corresponding V-grade surrounding rock support).The initial support is composed of 18# I-beam steel arch+26cm thick reinforced shotcrete, steel arch longitudinal spacing is 0.6m. Therefore, select the 1.2m blasting footage, so that any footage can support two pieces of steel arch. The initial design of blasting scheme (Figure 1) has fully token account of the shock and reducing the damage in the dyke by using smooth blasting technology.

In this scheme, the coupling coefficient K of the surrounding eye is set to 2.1, and reduces the blasting vibration by means of multiple drilling and less charge. Left hole is the first hole. The left side wall is dike with the thickness of only about 15m; in the right tunnel excavation blasting has been damaged to a certain extent. Therefore, the dyke integrity is worse than that of the right side wall. The dyke wall thickness is limited; the overall stiffness will be much smaller than that of the right wall. If the cut holes are symmetrically arranged in the middle of the tunnel, it can lead to the dyke vibration speed will be much larger than that of right side wall. It will also have a greater damage in dyke with original stress complex. Therefore, when the original blasting scheme cannot meet the requirements of the construction control, we decided to change the cut hole location to a certain extent.

After several tests, through the monitoring and analysis of the vibration, the settlement and convergence, we got the design scheme, which can meet the requirements of the engineering on the vibration and deformation of the surrounding rock. The blast hole arrangement is shown in Figure 2. The blasting parameters of the original blasting scheme and the new blasting scheme are shown in Table 1.

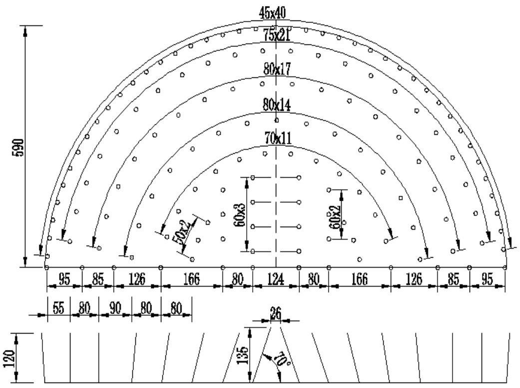

Fig.1 - The original blast holes layout /cm

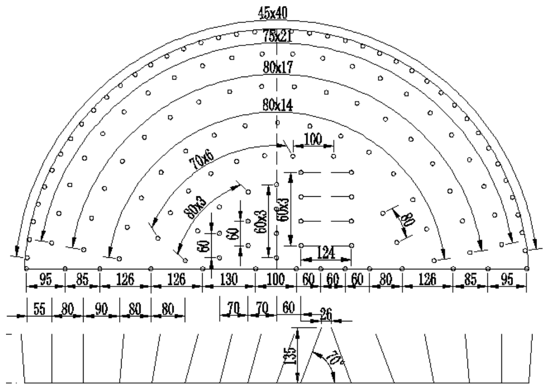

Fig.2 - The optimized blast holes layout /cm

Tab. 1 - Blasting parameters of two kinds of blasting schemes

Hole position	D/mm	N	H/m	De/mm	Cs/kg	Ca/kg
cut hole	42	8	1.35	35	1.10	8.80
auxiliary hole	42	79	1.20	35	0.50	39.50
peripheral hole	42	41	1.20	20	0.15	6.15
bottom hole	42	12	1.20	35	0.50	6.00
total		140				60.45
cut hole	42	8	1.35	35	1.10	8.80
auxiliary hole	42	77	1.20	35	0.50	38.50
peripheral hole	42	41	1.20	20	0.15	6.15
bottom hole	42	14	1.20	35	0.50	7.00
total		140				60.45

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D— blasting hole diameter [mm]
N—blasting hole amount
H—blasting hole depth [m]
De—explosive package diameter [mm]
Cs—single hole charge [kg]
Ca—accumulated charge [kg]

The optimization scheme is determined by several tests. When setting the blast hole, each time we move cut hole to the right 30cm. Then, the appropriately adjust the auxiliary hole and bottom hole near cut hole. As can maintain the total amount of blasting each time basically unchanged. Test and analysis of blasting vibration data wave were completed with TC-4850 type portable control blasting vibration meter produced by the Chengdu branch. TC-4850 type blasting vibration meter have multi channel acquisition capability. Field tests are shown in Figure 3.

(a) Vibration meter host *(b) Three-way vibration sensor*

Fig.3 - Blasting test site

Each measurement section away from the working face is 3m. Three measuring points are respectively layout at the dyke, vault and wall on the right side. The distance from measuring point of the sidewall to floor is 1.5m. Vibration sensor layout diagram are shown in Figure 4. The test results are shown in Figure 5.

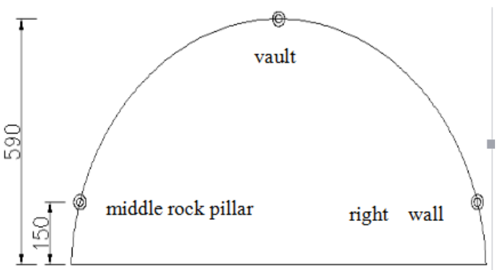

Fig.4 - Vibration sensor layout

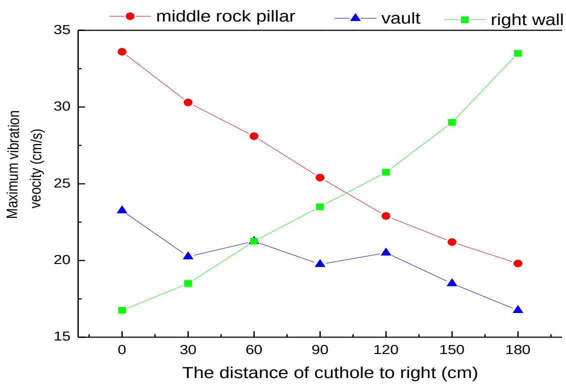

Fig.5 - Relationship between different cuthole position and surrounding rock vibration velocity

The tunnel blasting used emulsion explosives with safety and strong water resistance performance, from the measured explosives test data it can be seen that:

① When the cut hole is shifted to the right, the maximum seismic velocity of the dyke decreases rapidly and the maximum seismic velocity of the vault has no obvious change and the maximum seismic velocity of the right wall increases slowly.

② When the vertical centreline of the cut hole coincides with the vertical center line of the tunnel face, the maximum seismic velocities of the dyke, vault and right wall are 33.6cm/s, 24.3cm/s and 21.7cm/s. When the vertical centerline of the cut hole is about 95cm apart from the vertical center line of the tunnel face, the maximum seismic velocity of the dyke is equal to the maximum seismic velocity of the right wall. The maximum seismic velocity calculated by the difference method is about 24.5cm/s.

③ Considering the seismic resistance of the right wall is higher than that of the dyke rock wall, so move the cut hole to the right horizontal direction 120cm. The maximum vibration velocity of the dyke rock wall measured at this time is 22.9cm/s, which is 10.7 less than that of the undercut surface; the maximum vibration velocity of vault is 23.2cm/s, which is 1.1 less than that before optimization; The maximum vibration velocity of the right wall is 25.3cm/s, which is 3.6 higher than that before optimization. The optimized scheme significantly reduces the seismic velocity of the dykes by 31.8%, while the velocities of the vaults and the right walls do not change much.

④ The rate of residual marks of two blasting schemes in the blasting is about 75%.But before the optimization of the program, the maximum over-digging and the average over-digging of no optimized scheme are slightly better than that of the optimized scheme. The maximum over-digging and the average over-digging of no optimized scheme are 191mm and 82mm respectively; the maximum over-digging and the average over-digging of optimized scheme are 208mm and 95mm respectively. But that of the optimized scheme does not exceed the excavation limit of specification, so the optimized scheme can be accepted.

Surrounding rock reinforcement measures and its evaluation

The economic and practical methods to reinforce the surrounding rock are grouting and anchor reinforcement. Surrounding rock reinforcement can improve the mechanical properties of surrounding rock and improve its bearing capacity and seismic performance. The surrounding rock of the tunnel is argillaceous limestone with low strength and water softening seriously. Pre-grouting to surrounding rock around excavation contour line before excavation can not only strengthen the surrounding rock, but also can improve the permeability of the surrounding rock and reduce the loss of softening strength of surrounding rock.

Ring grouting after excavation to a certain extent, can repair the surrounding rock cracks due to blasting, increase the strength of surrounding rock and reduce the vault settlement and the surrounding rock convergence deformation.

Previous studies have shown: In soft rock, the use of pre-stressed anchor individually and the reinforcement anchors have little effect. By using the grouting reinforcement first and then combined with anchor reinforcement, the effect is obvious. This project also uses the reinforcement technology by pre-grouting first and then using reverse pull anchor in the dyke.

Commonly used grouting materials are common cement slurry, cement-water glass double slurry and ultra-fine cement slurry. Compared with other grouting materials, cement-water glass double slurry has environmental protection, coagulated speed controlling ability, easy preparation, good permeability and so on. It is suitable for tunnel rock reinforcement to meet the requirements of rapid tunnel construction. Under the same conditions, the diffusion radius and the coagulated time of cement-water glass double slurries are mainly determined by the concentration of the two slurries and the ratio of the two slurries. The main reactions of cement and water glass are as follows:

$$Ca(OH)_2+NaO\bullet nSiO_2+mH_2O\rightarrow Ca\bullet nSiO_2\bullet mH_2O+NaOH\ _3 \quad (1)$$

This reaction is much faster than the hydration reaction of the calcium silicate and dicalcium silicate in the cement slurry. The larger the proportion of water glass, the shorter the consolidation time of cement-water glass double-slurry, and the smaller the diffusion radius. Therefore, the coagulated time of cement-water glass double-slurry can be controlled according to the different ratio of cement water glass.

According to previous engineering experience and field simple test, we decided to take the water cement-water ratio at 1: 1, water glass concentration of 18Be′, control grouting pressure control at 3.5MPa;used double slurry pre-grouting firstly with cement slurry: water glass at 1:0.2 so that the double slurry can be fully spread, then used slurry grouting with cement slurry: water glass at 1:0.25 was done until the two slurries were quickly coagulated. The diffusion radius of double slurry with cement slurry: water glass at 1:0.2 is 2.5~3m, and the radius of double slurry with cement slurry: water glass at 1:0.25 is 2~2.5m.The initial coagulated time of this kind of grouting technology by cement-water glass double slurry is about 20s, and final coagulated time is about 360s.As can quickly strengthened the tunnel surrounding rock and enhance the stability of the tunnel after excavation.

When the grouting is completed about 2 hours, the ring anchor and reverse pull anchor can be built according to the design. The length of the ring anchor is 3m, and its spacing is 0.6×1.2m (longitudinal×ring). When the excavation reaches BZK0+830, the surrounding rock has undergone great deformation. Therefore, in the vicinity of BZK0 + 825, we use the optimized drilling and blasting scheme and reinforcement measures.

After changing the construction method the deformation of the monitoring points BZK0+830, BZK0+825 and BZK0+820 were compared and analyzed. The results are shown in Figure 6 and 7.

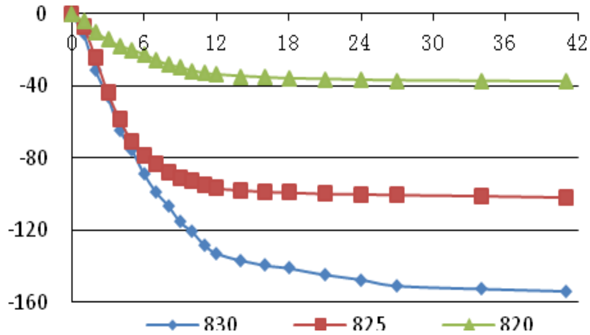

Fig.6 - Vault settlement curve for monitoring section of old and new construction method

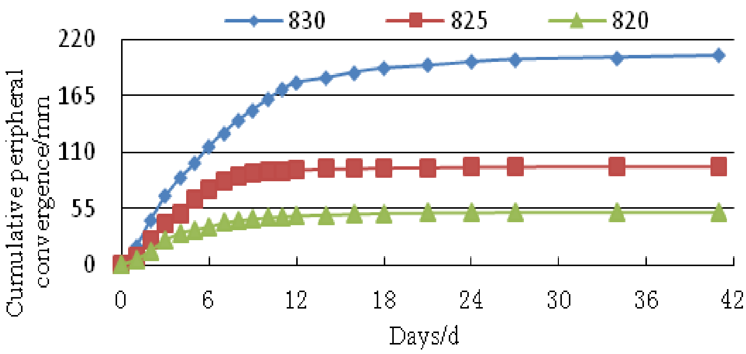

Fig.7 - Convergence curve for monitoring section of old and new construction method

The following results can be drawn from the Figures 6 and 7:

(1) The deformation law of the tunnel surrounding rock has the same growth rule when using two different construction methods, which are rapid growth about 10 days after excavation, and then the growth rate becomes slow and no deformation and abrupt change occurs. There is no sign of instability. Therefore, it is necessary to strengthen monitoring in the first two weeks after tunnel excavation, and the monitoring frequency can be reduced only when the surrounding rock deformation is stable.

(2) After changing the drilling and blasting design and the reinforcement measures to the surrounding rock, the cumulative settlement of the vault and the cumulative peripheral convergence of the tunnel are significantly reduced. The cumulative settlement of the vault is reduced from 153.62mm of BZK0+830 to 37.73mm of BZK0 + 820, the cumulative peripheral convergence is reduced from 204.17mm of BZK0+830 to 51.70mm of BZK0+820.The deformation of monitoring section BZK0 + 830 is greater than the reserved deformation of tunnel design 120mm, it will occupy the structural space of second liner lining or tunnel construction boundaries. But the improved construction method controls the tunnel deformation in a reasonable range.

CONCLUSIONS

Since the self-bearing force of surrounding rock in shallow-buried small spacing tunnel is usually low and the stress of dyke wall is complex, unreasonable blasting method will lead to large deformation of surrounding rock and even the collapse. Therefore, combined with the practical engineering, the reasonable optimizing the design of drilling and blasting design, improving the seismic performance of surrounding rock before blasting, reinforcing surrounding rock after blasting and repairing the damaged surrounding rock by blasting after blasting, the vault settlement and surrounding convergence of tunnel excavation are controlled in a safe and reasonable range. The conclusions are as follows:

(1) For the small spacing tunnel, arranging the cutting hole in one side away from the dyke is conducive to the protection of heavy load in the dyke. The distance of deviation should be determined by comparing the test explosion. The asymmetry of the holes makes the drilling and charging complicated, it will reduce the construction efficiency.

(2) The reinforcement effect of grouting reinforcement on soft surrounding rock is obvious. Reasonable selection of grouting material can be a practical and effective reinforcement for the surrounding rock stability. In this paper, the grouting parameters and grouting methods play an important role in the stability of the tunnel.

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