Study on Blasting Construction Technology of Tunnel Engineering in Soil-rock Interlaced Strata at Soft and Hard Rock Boundary

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Abstract. With the development of transportation construction and the acceleration of urbanization in China, the construction of urban highway tunnel engineering has also entered a new climax. In order to overcome obstacles in terrain and elevation such as railway construction, blasting technology for railway tunnel construction is widely used. However, due to the unhealthy and complex geological conditions of railway tunnels, and the unreasonable application of blasting technology, blasting safety accidents occur. Blasting technology in railway tunnel construction, but blasting construction is easily interfered by various external interference factors. In the tunnel face blasting construction under the condition of soil-rock crisscross composite stratum, not only the physical and mechanical properties of the lower surrounding rock should be considered, but also the engineering characteristics of the upper surrounding rock or surface rock mass have great influence on the construction blasting. Taking the actual project as an example, this paper expounds the tunnel engineering and geological conditions, and studies the blasting construction technology of the tunnel engineering in the soft and hard rock boundary soil-rock crisscross strata to ensure the safety of blasting construction.

1. Introduction
With the continuous development of urban rail transit, the bedrock depth is shallow occasionally in the construction process. In this case, drilling and blasting method is usually used for construction, but due to the subway construction is mostly located in the downtown area of the city, the existing structures on the surface are complex, and there are many existing pipelines in the stratum, certain vibration reduction measures must be taken to ensure the safety of surrounding buildings [1]. Under the condition of soil-rock cross composite stratum, the blasting construction of tunnel face not only needs to consider the physical and mechanical properties of the lower surrounding rock, but also has a significant impact on the engineering characteristics of the upper surrounding rock or surface rock [2]. Improper blasting scheme and construction parameters will often cause the upper rock loose, falling block, and even collapse. Because the construction site of urban highway tunnel is mostly in the center of the city, with a large population and dense surrounding buildings, the construction difficulty increases, and the construction process will have an impact on the safety of the surrounding environment [3]. The impact of urban highway tunnel construction on the safety of the surrounding environment is mainly the impact
of blasting vibration and the redistribution of surrounding rock stress caused by excavation [4]. Railway tunnel construction blasting technology, but due to the blasting construction is easy to be interfered by various external interference factors [5]. Therefore, it is necessary to take various effective measures to improve the quality and safety of blasting engineering according to the actual construction site.

Blasting mainly relies on the impact energy of high temperature and high pressure gas generated at the moment of explosive explosion, resulting in the impact, crushing and compression deformation of surrounding objects, so as to achieve the ideal blasting effect [6]. When blasting is required in the construction process of urban tunnel engineering, different blasting schemes should be adopted according to the different environment around the blasting area and different design requirements of the project, and various safety protection measures and strict blasting control should be taken to avoid adverse effects on the surrounding environment [7]. Shen Hongyun et al. Compared and analyzed the vibration reduction effect of different depth and width of the vibration reduction ditch and the vibration reduction effect when the relative depth of the vibration reduction ditch and the blast hole is different, and concluded that the width of the vibration reduction ditch has little effect on the vibration reduction effect, and the closer the vibration reduction ditch is to the face, the better the vibration reduction effect is [8]. Jia Wulong analyzed the influence of the number of vibration reduction grooves on the vibration reduction effect, and concluded that the vibration reduction effect of two vibration reduction grooves is better than that of a single one [9]. In tunnel excavation construction, in order to ensure the construction safety and construction quality as well as the safety of ground buildings, it is necessary to carry out information construction monitoring of blasting vibration caused by tunnel excavation blasting, so as to guide the design of blasting parameters and subsequent construction of tunnel engineering [10]. Taking the actual project as an example, this paper expounds the tunnel engineering and geological conditions, and studies the blasting construction technology of the tunnel engineering in the cross rock stratum with soft and hard rock boundary, so as to ensure the safety of blasting construction.

2. Analysis of safety accident causes and construction technology in blasting construction

In today's increasingly mature mechanical engineering, there are higher requirements for blasting accuracy and safety. Although traditional blasting has its advantages, uneven fragmentation and secondary fragmentation affect the progress and efficiency of the project, which obviously can not meet the requirements of mechanical construction for accuracy. For on-site construction, the purpose is to use the energy of explosion to exert on the blasting excavation area as much as possible, and to ensure the safety of the protection area and reduce the impact of blasting on it as much as possible. Therefore, it is necessary to control the damage energy of blasting vibration effect on the protection area within a certain safety range, which is usually called the safety criterion of blasting vibration. Smooth blasting technology has more advantages than traditional blasting technology, which can effectively control the blasting effect of surrounding hole explosive and minimize the disturbance of blasting process to surrounding rock [11]. So as to effectively maintain the stability of surrounding rock, give full play to the supporting role of surrounding rock, ensure the progress and safety of tunnel construction, at the same time, it can also reduce over excavation and under excavation, improve project quality and efficiency, and save project cost.

The delay time interval of single hole continuous initiation and vibration reduction technology of tunnel electronic detonator is very important to the effect of tunnel blasting. Too large delay time interval between holes affects the blasting footage and rock breaking effect of tunnel. If the delay time between holes is too small, the vibration reduction effect is not obvious, and sometimes the vibration increases. The schematic diagram of blasting vibration test system is shown in Figure 1.
In order to complete the project as soon as possible, construction enterprises generally do not have an internal blasting safety management department. Moreover, in some units that need to carry out blasting construction, the blasting safety management is supervised by other departments, among which these non-professionals are lax in their management, and the blasting work on the construction site is not regarded as an important thing to do, so when an accident occurs during the blasting project, no department that can bear the responsibility appears. When explosives are blasted in rock mass, they are divided into shock wave, stress wave and seismic wave according to propagation distance, and the thin bedrock roof is mainly affected by shock wave. The vibration distribution characteristics of surrounding rock near the working face under the action of shock wave will be analyzed by numerical simulation.

At present, many blasting construction enterprises are not perfect in their safety management system, and have not implemented the safety responsibility system management, so many safety management systems only stay in theory, without realizing the importance of safety management system. These situations directly lead to the lax supervision of safety management in the construction of construction enterprises, and also lay a hidden danger for the occurrence of safety accidents.

According to the actual conditions of foundation soil compactness, foundation surface flatness, the effect of blasting on drug-free areas and slopes, and the impact of blasting shock wave on the surrounding environment, etc., the appropriate blasting parameters, blasting quantity, blasting safety distance and other blasting technical indicators are determined [12]. Table 1 shows the optimized performance parameters of building layout before and after optimization. The simulation comparison of topology stability optimization is shown in Figure 2.

| Table 1. Optimized topology performance parameters of building layout before and after optimization |
|--------------------------------------------------|----------------|----------------|
| Before optimization | After optimization |
| Number of rows | 25 | 36 |
| Number of columns | 20 | 38 |
| Monitoring points | 500 | 1368 |

![Figure 1. Blasting vibration test system](image)
Before the construction, do a good job of blasting test, according to the representative parts of the test, judge the safety of initiation by observing the initiation phenomenon, and carry out blasting exploration to calculate the blasting rate. Before the construction, the blasting construction enterprises did not have relevant professionals to make technical disclosure on blasting safety, and they did not have a professional understanding of some professional equipment used in blasting, and they were not skilled enough to use it, so some blasting projects could not meet the requirements of pre-design. Because the explosive charge will be affected by high temperature, high pressure and gas expansion when it explodes, the tunnel soil is subjected to strong pressure such as shock wave and bubble pulsation, resulting in angular deformation and fracture of the soil. After analysis, when the relative position of the tunnel land changes when it is displaced, the gap and volume will be reduced, thus the soil will be compacted.

3. Effective countermeasures and suggestions on strengthening safety management of blasting construction

3.1. Strict blasting design
Before blasting construction, personnel who come into contact with explosives shall not carry with them mobile phones, lighters and other explosives that can detonate explosives, and the blasting safety supervision unit shall be responsible for supervision and inspection before running down the well. Blasting safety alert shall be taken charge of by specialized blasting subcontractors, and safety personnel of general contractor shall assist in peripheral blasting alert. After the blasting preparation work such as charging and wiring is completed and the blasting alert work is confirmed, the person in charge of the blasting subcontractors shall issue an order to initiate blasting. The interface between soil and rock has an important influence on the vibration of surrounding rock and supporting structure. The curve of radial peak vibration velocity inclines to the structural plane as a whole, and shows certain symmetry on both sides of the maximum measuring point of peak vibration velocity [13]. Blasting flyrock is mainly divided into two forms: throwing and throwing, and throwing flyrock is related to weak surface and crack in blasting medium. The explosives in rock mass produce high-temperature and high-pressure gas in the process of explosion, which quickly spreads to weak surfaces such as cracks, faults and peaks of rock mass. The explosive gas carries rock blocks and scatters in a projectile shape, with high speed and long throw distance, which has a great impact on blasting safety. In tunnel blasting, it is necessary to comprehensively consider the possible adverse factors such as humidity and airflow, and make use of
the advantages of GPS preparation to prepare and control the drug distribution, so as to provide basic conditions for the construction quality.

Before blasting operation, blasting subcontractors shall accept the blasting eye holes. After the eye holes pass the acceptance, the blasting construction technical director, technical supervisor of civil construction unit, blasting safety supervisor and civil construction supervisor shall confirm and sign them and hand them over to blasting subcontractors. It has great advantages to use the powerful spatial information processing ability of GIS to express the blasting construction process of tunnel engineering in soil-rock crisscross strata. The structural design of the system is shown in Figure 3.

When a construction enterprise is engaged in blasting construction, it must ensure that the blasting design of its construction project is reasonable and scientific, the designers of its construction enterprise must have professional knowledge, and the level of blasting must meet its professional standards. In order to ensure the safety of blasting, before blasting, special personnel shall be on-site alert in real time, and irrelevant personnel shall be evacuated from the site. During blasting, inflammable and explosive materials and human activities are strictly prohibited in the operation area [14]. The data of peak value of vibration caused by blasting in the actual field construction is similar to that of the case where no damping ditch is set in the numerical simulation, and the development trend of curves is roughly the same. However, due to the complex field geological conditions, the controllability of construction quality is poor. Therefore, under the condition of no vibration reduction measures, the peak vibration velocity of the measuring point with small explosion center distance is slightly larger than the numerical calculation result, but the difference is small, so the numerical calculation is effective.

3.2. Environmental impact control of blasting construction

According to the safe distance, the safe distance of blasting is determined according to the safe range of explosion effect on environment and relevant calculation formulas, and then the dosage is controlled to reduce the impact of underwater shock wave and blasting vibration and the pollution of explosive products. Before the implementation of the design, the site of construction blasting must be strictly inspected again, and the surrounding environment should be surveyed again, so as to design a blasting design that conforms to the site conditions. When designing the blasting construction scheme, it is necessary to analyze the causes of some hazards involved, and then adjust according to the causes, so that the hazards caused by blasting can be controlled within a certain controllable range [15]. If the
blasting construction enterprise carries out the blasting operation in a complex environment, its blasting operation must be carried out in strict accordance with the national regulations, and the blasting construction design scheme must be adjusted according to its actual environment at the blasting site, so as to minimize the risk factors encountered.

During blasting, it is necessary to do a good job in safe power consumption management, fire and explosion prevention management, traffic safety management, tunnel operation safety management, site general layout management, workers' safe and civilized construction management, etc., and make timely work hazard analysis and control records as an important basis for safety management and handling sudden safety accidents. In the process of blasting operation in some cities, the construction geology has very complex characteristics, including softening rocks and hard rocks, and the distribution structure of rocks is very uneven. These conditions have a certain impact on blasting construction, but through scientific blasting engineering scheme design and the use of advanced blasting technology, the blasting engineering has achieved the expected results.

4. Conclusions
After repeated blasting experiments and based on the monitoring data and regression analysis, the blasting parameters were further optimized and adjusted, and measures were taken to control the driving footage, control the maximum explosive charge in the section, start blasting in batches for many times, and drive small pilot tunnels by steps, so as to control the blasting vibration effect at a lower level. Because blasting construction is easily interfered by various external interference factors, it is necessary to take various effective measures to improve the quality and safety of blasting engineering according to the actual construction site. Near the interface between soft and hard rock, the vibration velocity of rock mass is negatively correlated with the elastic modulus ratio, that is, the vibration velocity of rock mass decreases with the increase of the elastic modulus ratio of rock mass on both sides of the interface. Before blasting operation, blasting subcontractors shall accept the blasting eye holes. After the eye holes pass the acceptance, the blasting construction technical director, technical supervisor of civil construction unit, blasting safety supervisor and civil construction supervisor shall confirm and sign them and hand them over to blasting subcontractors. Because the explosive charge will be affected by high temperature, high pressure and gas expansion when it explodes, the tunnel soil is subjected to strong pressure such as shock wave and bubble pulsation, resulting in the phenomenon of soil angular deformation and fracture. Therefore, according to the relevant blasting engineering experience data of railway tunnel, the blasting should be carried out in sections and layers.

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