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Technical Development and Safety Risk Analysis of Urban Underground Engineering

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ABSTRACT

With the rapid development of China's urban construction, the acceleration of urbanization and the rapid expansion of population, the effective development and utilization of urban underground space have attracted great attention. Therefore, it is inevitable to study the comprehensive technology of deep underground engineering, and the research results will play an important guiding role in the design and construction of middle and shallow space of underground engineering in the future. This paper analyzes several common construction techniques and methods in the current construction process of urban underground engineering, summarizes the main construction methods of underground engineering, forecasts the development of urban underground engineering construction, and analyzes the safety risks of urban underground engineering construction.

1. Development Trend of Urban Underground Engineering

There is a popular view internationally that "the 19th century is the century of roads and Bridges, the 20th century is the century of tall buildings, and the 21st century is the century of underground space".

^[1] Since the middle of the 20th century, with the acceleration of urbanization in the world, urban land has become increasingly scarce, and the problems of backward infrastructure and environmental deterioration have become increasingly prominent. In order to solve these problems, some developed countries in the world began to use the

underground space of cities. The European and American countries and Japan were the first to develop and utilize underground space. Among them, European countries have made good use of underground space, which greatly alleviates the shortage of urban land through extensive construction of subway, underground shopping malls, underground warehouses and underground comprehensive service areas. After entering the 21st century, with the acceleration of China's urbanization process and the rapid economic development, Chinese cities are carrying out large-scale underground space construction (such as subway, underground shopping mall, underground ga-

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rage, and underground reservoir). The utilization of urban underground space will also develop from the current shallow space to the middle and shallow space (30 m below the surface). The complex theory and key technology of underground engineering construction involved in the development of underground space in deep cities in China are still lack of in-depth and systematic research. Therefore, it is inevitable to carry out comprehensive technical research on ultra-deep and complex underground engineering, and its research results will play an important guiding role in the design and construction of underground engineering in middle and shallow space in the future.

The construction of urban underground engineering is carried out inside the underground rock and soil body. Therefore, its construction is very different from the construction of ground buildings. The construction of underground engineering mainly has the following characteristics: (1) it is greatly influenced by the engineering geological and hydrogeological conditions; (2) poor working conditions, narrow working face and poor working environment; (3) underground excavation has little impact on the ground, but it may lead to ground subsidence when buried in a shallow place; (4) large amount of waste soil and gravel should be properly treated. The mechanical deformation, construction conditions and technical difficulty of the tunnel and underground engineering are quite different from the surface structure. Generally speaking, its risk and risk are higher than the surface structure.^[2]

2. Main Construction Techniques of Underground Engineering

The key to the success or failure of urban underground engineering is the construction problem. The selection of construction method should be determined by technical and economic comparison according to the factors such as the nature of the project, scale, conditions of soil and rock strata, environmental conditions, construction equipment and time limit. The construction method should be safe and applicable, technically feasible and economically reasonable. China has made great progress in the construction technology and method of underground engineering, and has successively adopted the research and application of construction technology methods such as open excavation method, reverse method, underground excavation method, caisson method, shield construction method, pipe jacking method and submerged pipe method, some of which have reached the international advanced level.^[3]

2.1 Excavation Method

Open excavation method, also known as foundation pit excavation technology, has the advantages of simple construction, safety, speed and economy, and its disadvantages

are mainly greater impact on the surrounding environment. Open excavation method is suitable for open ground and better underground geological conditions. The open excavation method is mainly used in the engineering practice of a large number of deep foundation pit projects, and has formed a complete variety of foundation pit enclosure excavation technology.^[4]

2.2 Reverse Method

The reverse method is based on the underground structure itself as the wall, and also as the supporting system, which is the construction method of digging and constructing the underground structure system step by step from top to bottom. Because it works in reverse with the traditional sequence construction method of first supporting and then digging, it is called reverse operation. The principle of reverse action is supported by the structural phenomenon (floor system), whose stiffness is quite large, which also reduces the overall deformation of the supporting structure, showing obvious advantages. Reverse action needs to set up temporary column and column pile first, want to increase a few expenses, and in each stage of concrete casting, cast first and cast after working procedure, its junction brings inconvenience to construction.

2.3 Concealed Excavation Method

Underground excavation construction technology is under the surface of the construction, the advantages of life without interference, but the technical requirements and high cost. There are three kinds of working methods: new Austria method, shallow excavation method and pipe curtain method.^[5]

2.3.1 New Austrian Tunnelling Method

New Austrian Tunnelling Method is a kind of tunnel design and construction method, which is designed to make surrounding rock form a hollow tubular support ring structure.

2.3.2 Shallow Excavation Method

Shallow buried and dark excavation is a method of underground excavation for various types of underground caverns near the surface of soft soil layer, which is based on strengthening and treatment of weak stratum and adopts sufficiently rigid composite lining (composed of initial support, secondary lining and intermediate waterproof layer) as the basic supporting structure.

2.3.3 Pipe Curtain Method

The pipe curtain method is based on the single pipe jacking, and each single pipe is connected by the lock port to form a pipe row on the side of the steel pipe, and grouted between the lock ports to form a sealed stop pipe curtain,

which is then reinforced to the soil in the pipe curtain, and finally excavated and supported inside the pipe until the pipe segment is through and then poured the structure.

2.4 Open Caisson Method

Caisson sinking method, also known as caisson sinking method, is a special construction method for constructing vertical shaft in unstable water-bearing stratum. When a shaft is dug into a shaft by unsteady water-bearing stratum, a section of shaft is prepared on the designed shaft position. The shaft has a blade foot at the lower end.

2.5 Shield Method

Shield tunnel construction method refers to the method of building tunnel without disturbing surrounding rock by using shield machine to control the excavating surface and surrounding rock at the same time without collapse and instability, and carrying out tunnel excavation at the same time. Shield is widely applicable. Tunneling allows the construction of underground structures below the longitudinal length, with shallow overburden, which will not cause surface fracture or large subsidence in unstable stratum and ground water bearing stratum. It can be used in very loose soil or high pressure and strong stratum, such as soft and plastic stratum or flowing stratum, and also realized effective application in temporarily stable stratum, playing the role of top protection. Therefore, shield construction method has a broad application range and prospect.

2.6 Pipe Jacking Method

The pipe jacking method is to use hydraulic jacks or equipment with jacking and traction function. The pipe jacking working well is used as the pressure wall. While the stratum is excavated, prefabricated underground pipes (or tunnels) are pushed forward in sections along the design route together to the destination. It is a kind of underground construction method for tunnel or underground pipeline crossing various obstructions such as railway, road, river or building.

2.7 Immersed Tube Method

The submerged pipe method is also called precast pipe section sinking method, that is, the reinforced concrete structure is preloaded in the dock, and the water is discharged to float and then buried to the designed position to build the underwater project. This method is easy to guarantee the quality of tunnel construction, low project cost, short construction period in the tunnel site, good operating conditions, safe construction, wide range of water depth, free choice of section shape and size, section space can be fully utilized, but the drawback is high technical requirements.

3. Technical Prospect of Urban Underground Engineering Construction

The effective utilization of underground space will be a new land resource to benefit mankind. As domestic rapid advance of urbanization, land resources quickly reduce bring to people's life followed by a series of problems, while the development of urban underground space can effectively alleviate the urban traffic problems, improve the city's comprehensive disaster prevention ability, improving urban environment on the ground, so the reasonable development and utilization of urban underground space has become the inevitable trend of city development, it also bring huge development opportunities for geotechnical engineers.

The construction technology of urban underground railway is the main direction of the future development of urban underground engineering in China. The construction method of tunnel and station should be chosen according to local conditions to shorten the construction period, save investment and double the result with half the effort. We should focus on developing new construction methods, construction equipment and construction techniques suitable for China's national conditions in the 21st century, which will accelerate the construction speed of China's subway project and effectively improve the development of China's urban underground transportation.

4. Safety Risk Analysis of Underground Engineering Construction

Underground engineering construction is characterized by large investment, high complexity, strong concealment, long construction period and uncertainty of surrounding environment.^[6] Therefore, in the process of concrete construction, there are a lot of risk factors, especially some risk factors, it is not easy to be found lurking in the process of project construction and combined with the current underground engineering construction safety risk management system in our country is not perfect enough, related engineering safety management standard is not perfect, increased the occurrence of safety accidents in underground engineering, to the modern society economy and environment have brought many bad effects. And according to the specific condition of underground engineering construction, build a set of scientific, rational and feasible security risk management system, effectively for the underground engineering construction is the whole process of risk management, advance the security risks existing in the construction process of science assessment, not only can radically enhance the construction management department of risk management consciousness and ability, still can greatly reduce the occurrence of safety accidents

in the process of underground project construction, ensure the safety of underground engineering construction.

4.1 The Safety Risk Management System Is Not Sound

In the underground engineering construction safety risk management, while also issued a series of our country has a guidance document, but the safety risk management in the underground engineering construction, never build a relatively perfect system of laws and regulations, to the status of the risk management of project construction and the importance of accurate positioning, lead to underground engineering construction safety risk management also temporarily in a state of disorder, the management of content and process didn't have a set of standards as the basis, lead to underground engineering construction safety risk management is difficult to obtain the ideal effect.^[7]

4.2 The Safety Risk Management Is Underfunded

Due to budget, at the early stages of the underground project construction will be no risk of construction safety management costs money and use the standard for clear rules, causes responsible for the construction contractor in order to increase their own economic interests, and reduce the investment in capital construction safety risk management, lead to a serious shortage of funds in security risk management, a lot of security risk management work are not normal, for the construction of the underground engineering is buried under the great potential safety hazard.

4.3 The Project Monitoring Is Not In Place

Monitoring quality of construction projects is an important risk avoidance strategy, a lot of practice shows that if you can further enhance the quality of the engineering monitoring, and can be scientific and reasonable to evaluate the safety of the engineering construction risk, can effectively improve the safety of underground engineering construction, can effectively reduce the incidence of security risks. However, as far as the current construction situation is concerned, in most underground engineering construction, there is no set of effective standards for the project monitoring market, which has a great impact on the effectiveness and accuracy of the project monitoring data and cannot provide scientific and accurate data information for the implementation of safety risk management.

5. Construction Method of Safety Risk Management System for Urban Underground Engineering Construction

5.1 Establish a More Complete Safety Risk Management Plan

In charge of underground engineering construction unit

must develop a set of feasible safety risk management plan, through the risk management plan to improve the safety of construction personnel management consciousness, and referring to the management plan as a key component part of the underground engineering construction, it can not only contribute to the safety of the relevant personnel to make the right risk management decision, also can effectively reduce the incidence rate of construction safety accidents, ensure the life property safety of the construction personnel and related businesses. Therefore, the units in charge of underground engineering construction must strictly implement the safety risk management plan standards, and timely adjust and revise the specifications that may constitute safety hazards. In an actual underground engineering construction, the comprehensive safety risk management of the risk analysis and evaluation, timely find the source of risk and risk existing in the construction process, according to the degree of risk, the risk may cause safety accident, the consequences of safety accident happens to build a complete monitoring system, in a timely manner according to the relevant contents in monitoring system using scientific and reasonable prevention and treatment measures, avoid and reduce the safety risk.

5.2 Improve Relevant Laws and Regulations on Safety Risk Management of Underground Construction

In underground engineering construction safety risk management work, the construction unit should strengthen, the ministry of railways and ministry of construction, the ministry of communications and the cooperation between other departments, formulate a set of relatively complete specifications and standards, to guide the safety risk management work smoothly, and risk management of construction safety in the standard specification of cost budget, determine the safety risk management in the position and the importance in underground engineering construction, strictly funds audit supervision, to ensure the maintenance funds can be fully applied to the safety risk management.

6. Conclusion

The construction of underground engineering in China should constantly develop existing technologies, study the technologies that are being applied abroad, introduce and absorb them into their own technology in combination with the national conditions, and catch up with the international advanced level through efforts. At the same time, the development of underground engineering construction technology is bound to have a greater impact on the development of urban construction technology in China and

make due contributions to the utilization and development of underground space in the 21st century.^[8]

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