RESEARCH ARTICLE

Research on ground subsidence control technology caused by subway tunnel construction in soft soil area

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Abstract: Under the background of accelerating urbanization process, subway construction has become an important means to solve the problem of urban traffic congestion. However, ground subsidence is a common and strictly controlled problem during subway tunnel construction in soft soil areas. Due to the unique characteristics of soft soil itself, the disturbance in the construction process is easy to lead to soil deformation and ground subsidence, which has a great impact on the safety and smooth progress of subway tunnel construction. Therefore, it is very important to study the ground subsidence control technology caused by subway tunnel construction in soft soil area.

Keywords: Soft soil area; Subway; Tunnel; Ground subsidence; Control technology

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1 Mechanism of ground subsidence in subway tunnel construction in soft soil area

With the acceleration of the urbanization process, as an important part of the urban public transportation, the subway construction scale is constantly expanding. However, subway tunnel construction in soft soil areas often faces the severe challenge of land subsidence. Due to its unique geological conditions, such as high water content, low strength and high compressibility in the soft soil area, the soil disturbance and deformation control in the tunnel construction process become technical problems. This paper aims to explore the control technology of ground subsidence caused by the construction of subway tunnel in the soft soil area, analyze the settlement mechanism, summarize the advantages and disadvantages of the existing control technology, and propose the improvement scheme to provide reference for related engineering practice.

1.1 Basic characteristics of soft soil

Soft soil refers to a kind of soil with high natural water content, high compressibility, low shear strength and poor water permeability, which is widely distributed in coastal areas, along the river and surrounding lakes. In the construction of subway tunnel, the geological conditions of the soft soil area are particularly complex, which puts forward higher requirements for the construction safety and quality[1]. The main characteristics of the soft soil include:

High water content: High water content in soft soil, often in a saturated state, resulting in low soil strength, poor stability.

Low strength: The shear strength of soft soil is low, prone to shear damage.

High compressibility: When the soft soil is subjected to the external force, the compression deformation occurs easily, leading to the foundation settlement.

Poor water permeability: The permeability coefficient of soft soil is small, and the drainage is difficult, which is easy to form a water stagnation layer.

1.2 The main causes of ground subsidence

Land subsidence caused by subway tunnel construction is the result of multiple factors, mainly including the following aspects:

Soil disturbance: In the process of tunnel excavation, the surrounding soil is disturbed, and the original stress balance is broken, leading to the displacement and deformation of the soil.

The extrusion effect of the shield machine through: In the process of propulsion, the shield machine squeethe surrounding soil, making the soil compress and deformation.

Force of tunnel lining structure on soil: In the process of tunnel lining structure, additional stress is exerted on the surrounding soil, which further aggravates the deformation and settlement of soil.

Change of underground water level: The precipitation measures during the tunnel construction will change the underground water level, leading to the increase of the effective stress of the soil and the settlement of soil consolidation.

2 Research on the existing land subsidence control technology

2.1 Construction process optimization

The optimization of construction technology is one of the important means to control ground settlement. By reasonably arranging the construction sequence, controlling the excavation progress and optimizing the shield tunneling parameters, the disturbance to the surrounding soil can be reduced, so as to reduce the risk of ground settlement. For example, the construction method of segmented excavation and layered support can effectively control the stability of the excavation surface and the deformation of the soil[2].

2.2 Soil reinforcement technology

Soil reinforcement is an effective measure to enhance the strength and stability of soil. In the construction of subway tunnel, the commonly used soil reinforcement techniques include grouting reinforcement, mixing pile reinforcement, and freezing method, etc. The grouting reinforcement improves the strength and stiffness of the soil by injecting cement slurry or other curing materials into the soil; the mixing pile reinforcement micement with soil to form a mixing pile with certain strength; the freezing method freezes the surrounding soil to support and stop water.

2.3 Ground-water level control

The change of groundwater level has an important influence on ground subsidence. In the construction process of subway tunnel, effective measures should be taken to control the groundwater level to avoid the settlement of soil consolidation caused by the rapid decline of the groundwater level. Commonly used groundwater level control methods include dewatering well dewatering, recharge well recharge, etc[3]. Precipitation wells reduce the groundwater level by extracting groundwater, and recharge wells inject clear water or groundwater into the stratum to maintain the stability of the groundwater level.

2.4 Monitoring and early warning system

The establishment of a perfect monitoring and early warning system is an important guarantee for the timely discovery and treatment of land subsidence problems. In the process of subway tunnel construction, the monitoring of surface settlement, groundwater level and soil stress should be strengthened, and the abnormal situation should be found in time and measures should be taken to deal with it. At the same time, an early warning mechanism should be established. When the monitoring data exceeds the preset threshold, the early warning signal should be issued in time so as to take countermeasures.

3 The inadequacy of the existing control technology

Although the existing control technology can effectively control the ground subsidence caused by the subway tunnel construction to a certain extent, there are still the following deficiencies:

The optimization of the construction technology is

not systematic and targeted: The geological conditions and construction environment of different projects are different, so the optimization scheme needs to be formulated according to the specific situation, but the optimization of the existing construction technology is often not systematic and targeted.

The reinforcement effect of soil body is unstable: The reinforcement effect of soil body is affected by many factors, such as the performance of reinforcement materials and reinforcement process parameters, which leads to the unstable reinforcement effect, and it is difficult to ensure the long-term effect[4].

The monitoring and early warning system is not perfect: Some projects are insufficient in the construction of the monitoring and early warning system, the monitoring data is not comprehensive and accurate, the early warning mechanism is not sensitive enough, and it is difficult to find and deal with problems in time.

4 Improvement scheme and future research directions

4.1 Improvement scheme

In view of the deficiency of existing control technology, the following improvement scheme are proposed:

Strengthen the systematic and targeted optimization of construction technology: According to the specific geological conditions, construction environment of the detailed construction technology optimization scheme, and strengthen the dynamic adjustment and monitoring in the construction process, to ensure that the construction process can minimize the disturbance to the surrounding soil.

Research and development of new soil reinforcement materials and technology: To increase the research on new soil reinforcement materials, such as high-performance cement-based materials, biological enzyme curing agent, etc., to improve the reinforcement effect and stability. At the same time, new reinforcement technologies, such as microwave heating and curing, and electrochemical reinforcement, are explored to meet the reinforcement needs under different geological conditions.

Improve the monitoring and early warning system: Establish a more comprehensive and accurate monitoring network, covering the surface subsidence, groundwater level, soil stress, tunnel structure deformation and other aspects. Advanced monitoring technologies, such as optical fiber sensing technology, are adopted to improve the real-time and accuracy of monitoring data. At the same time, the early warning algorithm is optimized to improve the sensitivity and accuracy of the early warning system, so as to ensure that it can respond quickly and take measures when abnormal situations are found[5].

Strengthen the construction management and quality control: Strengthen the quality management in the construction process to ensure that the construction measures are effectively implemented. Establish a sound quality management system, monitor and record the whole construction process, and find and correct the problems in time. At the same time, strengthen the training and education of construction personnel, improve the skill level and safety awareness of construction personnel.

4.2 Future research direction

With the continuous progress of science and technology and the deepening of engineering practice, the research on ground subsidence control technology caused by subway tunnel construction will present the following development trend:

Intelligent construction technology: Use artificial intelligence, big data and other advanced technologies to achieve intelligent control of the construction process. Through real-time monitoring and data analysis, the deformation trend of the soil in the construction process is predicted, and measures are taken to intervene and adjust in advance, so as to realize the effective control of the land settlement.

Green construction technology: While controlling ground subsidence, pay attention to environmental

protection and sustainable development. Develop and promote green construction materials and technologies to reduce carbon emissions and environmental pollution during the construction process. At the same time, explore the comprehensive utilization of underground space to improve the utilization efficiency of land resources.

Multi-disciplinary integration: The ground subsidence control caused by subway tunnel construction involves civil engineering, geological engineering, environmental engineering and other disciplines. Future research will pay more attention to the cross-integration and collaborative innovation between multiple disciplines to form a comprehensive solution and technology system[6].

Long-term monitoring and evaluation: Strengthen the long-term monitoring and evaluation of ground settlement after subway tunnel construction. Through long-term tracking of the change trend of monitoring data, the law and characteristics of ground subsidence are analyzed to provide scientific basis and reference for future engineering practice. At the same time, a perfect evaluation system and method are established to make an objective and comprehensive evaluation of the control effect.

5 Conclusion

The ground subsidence caused by subway tunnel construction in soft soil area is a complex and severe problem, which needs to be solved by various control technologies and management means. The risk of ground subsidence can be effectively controlled by optimizing the construction technology, strengthening the soil reinforcement, controlling the groundwater level, and improving the measures of monitoring and early warning system. Future research should continue to explore the directions of intelligent construction technology, green construction technology and interdisciplinary integration, so as to provide a more powerful guarantee for the safety and quality of subway tunnel construction. At the same time, long-term monitoring and evaluation should be strengthened to provide scientific basis and reference for engineering practice and promote the sustainable development of subway construction.

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