

Application of High-pressure Jet Grouting Pile in Deep Foundation Pit Excavation and Support Scheme around the Original Natural Foundation

Xiaoyan Qin*

China Energy Longyuan Environmental Protection Co., Ltd., Beijing, China

12005750@chnenergy.com.cn

**Corresponding author*

Keywords: High pressure jet grouting pile, Natural foundation, Deep foundation pit excavation and support scheme

Abstract: This paper discusses the application of high-pressure jet grouting pile in deep foundation pit excavation and support around the original natural foundation. Through the analysis of background and problems, this paper puts forward concrete solutions such as construction technology, parameter selection and on-site monitoring of high-pressure jet grouting pile. At the same time, combined with practical engineering cases, the successful application of this scheme is analyzed. The research shows that high-pressure jet grouting pile is an effective supporting scheme for deep foundation pit excavation, with high safety and reliability. It has a wide application prospect in deep foundation pit excavation and support scheme, which can effectively improve the bearing capacity and stability of soil, prevent soil displacement and collapse, and play a waterproof role; At the same time, it is convenient to operate and has low requirements for equipment, which can shorten the construction period and reduce the construction cost. Has a significant advantage. In practical engineering, the appropriate parameters and construction technology of high-pressure jet grouting pile should be selected according to the specific situation to obtain the best supporting effect.

1. Introduction

With the acceleration of urbanization and the increasing height and density of buildings, deep foundation pit excavation and support has become an important engineering and technical problem [1]. Deep foundation pit excavation around natural foundation often encounters a series of challenges, such as safety problems such as settlement and collapse of soft soil foundation, as well as construction period and cost [2]. In order to solve these problems effectively, the high-pressure jet grouting pile technology came into being and played an increasingly important role in the excavation and support scheme of deep foundation pit [3]. High-pressure jet grouting pile technology is an advanced reinforcement technology. The curing agent is sprayed into the soil through a high-pressure rotating nozzle, so that it can be quickly mixed and hardened, thus forming a pile with certain strength and stability [4]. This technology has the advantages of rapid solidification, high anti-leakage effect,

simplicity and so on, and is especially suitable for deep soil reinforcement. In the scheme of deep foundation pit excavation and support, high-pressure jet grouting pile technology can effectively improve the strength and stability of soil, prevent soil displacement and collapse, and also play a waterproof role [5].

The problems faced by deep foundation pit excavation around natural foundation mainly include soft soil foundation settlement and collapse [6]. Because of its high water content, low bearing capacity and easy compression, soft soil foundation often leads to uneven settlement and collapse of buildings, which seriously affects the safety and stability of the project [7]. In addition, problems such as rich groundwater and complex geological conditions may be encountered in the process of deep foundation pit excavation, which increases the construction difficulty and cost. High-pressure jet grouting pile technology has obvious advantages in solving the above problems [8]. First of all, it can quickly mix the curing agent with the soil by high-pressure jet to form a high-strength pile, thus improving the bearing capacity and stability of the soil and effectively preventing settlement and collapse [9]. Secondly, the high-pressure jet grouting pile has a good waterproof effect, which can effectively block the erosion of groundwater and ensure the dry environment during the excavation of deep foundation pit. Finally, the high-pressure jet grouting pile technology is simple and fast, which can greatly shorten the construction period and reduce the construction cost. This paper will discuss in detail the application of high-pressure jet grouting pile technology in the excavation and support scheme of deep foundation pit around the original natural foundation, including the specific technical implementation process and design points.

2. Technical principle and characteristics of high-pressure jet grouting pile

The basic principle of high-pressure jet grouting pile technology is to spray curing agent (usually cement slurry, cement mortar or chemical agent, etc.) into soil in the form of high-pressure jet by using the rotating nozzle of high-pressure jet equipment [10]. After the curing agent is mixed with soil, it quickly hardens through physical and chemical reactions, forming a pile with certain strength and stability. The pile of high-pressure jet grouting pile can effectively improve the bearing capacity and stability of soil, prevent soil displacement and collapse, and also play a waterproof role.

Technical characteristics of high-pressure jet grouting pile: high-pressure jet grouting pile technology adopts high-pressure jet mode, which can penetrate deep soil and make the pile reach a larger diameter and depth. High-pressure spraying can also fully stir and mix the soil to ensure the full contact between the curing agent and the soil. Rotating nozzle: The key equipment of high-pressure jet grouting pile technology is rotating nozzle, which can spray curing agent at high speed [11]. The design of rotating nozzle can ensure the curing agent to rotate continuously during the spraying process, so that the pile body presents a cylindrical shape. Rapid curing: the curing agent used in high-pressure jet grouting pile technology can be quickly mixed with soil and hardened in a short time to form a pile with high strength. This characteristic makes the high-pressure jet grouting pile technology adapt to various engineering conditions, and the construction speed is fast and efficient. Environmental protection: the curing agent used in high-pressure jet grouting pile technology is mostly cement, which has good environmental protection. Compared with the traditional support methods, the high-pressure jet grouting pile technology has less construction noise and less environmental pollution, which meets the environmental protection requirements of modern engineering construction. Wide scope of application: High-pressure jet grouting pile technology is suitable for various soil types, including soft soil foundation and sandy soil foundation. This characteristic makes the high-pressure jet grouting pile technology have a wide application prospect in various projects.

3. Application of high-pressure jet grouting pile in deep foundation pit excavation and support

High-pressure jet grouting pile is suitable for deep foundation pit excavation and support engineering under various soil conditions, especially for the following situations: ① Soft soil foundation: High-pressure jet grouting pile can effectively improve the bearing capacity and stability of soft soil foundation and prevent foundation settlement and collapse. ② Sandy soil foundation: High-pressure jet grouting pile can effectively reinforce sandy soil foundation and improve its liquefaction resistance, which is suitable for deep foundation pit excavation and support in desert, river bank and other areas. ③ High water level area: High-pressure jet grouting pile has good waterproof performance and is suitable for deep foundation pit excavation and support engineering in high water level area. ④ Complicated geological conditions: High-pressure jet grouting pile is suitable for deep foundation pit excavation and support engineering under various complicated geological conditions, such as karst, underground river and other geological conditions.

The design of high-pressure jet grouting pile mainly includes the following aspects: ① Determine the position and shape of pile: According to the requirements of supporting scheme, determine the position and shape of high-pressure jet grouting pile to ensure that the pile can effectively strengthen the soil and improve its stability. ② Determination of pile diameter and depth: According to the depth of deep foundation pit excavation and soil conditions, determine the diameter and depth of high-pressure jet grouting pile to ensure that it can achieve sufficient reinforcement effect. ③ Determine the type and dosage of curing agent: according to the soil type and engineering requirements, select the appropriate type and dosage of curing agent to ensure the strength and stability of the pile. ④ Determination of construction process parameters: According to the engineering conditions and actual conditions, determine the construction process parameters of high-pressure jet grouting pile, such as injection pressure, rotation speed, curing agent flow rate, etc.

The steps of the construction technology of high-pressure jet grouting pile are as follows: drilling: use a drilling machine to drill holes at selected positions to ensure that the aperture, depth and verticality meet the design requirements. Installation of nozzle: Install the rotary nozzle to the bottom of the borehole to ensure its good sealing. High-pressure injection: the curing agent is injected into the soil at a certain pressure through a high-pressure pump, and the rotating nozzle is controlled to rotate at a set speed. Standing and hardening: after spraying, standing for a period of time to make the curing agent fully react with the soil and harden. Displacement and repeated construction: move the drilling machine to the next construction position and repeat the above steps to complete all piles. Taking the deep foundation pit excavation and support project of a high-rise building in a city as an example, the project is located around the original natural foundation with complex geological conditions. In order to ensure the safety and stability of engineering construction, high-pressure jet grouting pile is used for support. Through careful design and strict construction, the task of deep foundation pit excavation and support of this project is finally successfully completed, which proves the effectiveness of high-pressure jet grouting pile in deep foundation pit excavation and support scheme.

4. Improvement and optimization of high-pressure jet grouting pile technology

High-pressure jet grouting pile technology has become an important technical means in deep foundation pit excavation and support scheme. However, with the deepening of engineering practice, some shortcomings of high-pressure jet grouting pile technology have also been found. In order to improve the supporting effect, shorten the construction period and reduce the cost, the high-pressure jet grouting pile technology should be improved and optimized.

4.1 Improvement of high pressure jet grouting pile technology

In terms of material selection: curing agent materials with higher strength and better durability can be selected, such as using high-strength cement or adding additives, to improve the strength and stability of the pile. Process improvement: by optimizing the structure of high-pressure jet grouting equipment, increasing the rotation speed and changing the injection mode of curing agent, the construction efficiency and pile quality of high-pressure jet grouting pile are improved. In addition, composite support can be used to combine high-pressure jet grouting pile with other support methods to form a multi-level and diversified support system to improve the support effect and safety.

4.2 Optimization of high-pressure jet grouting pile technology

Firstly, the computer simulation technology can be used to simulate the construction process of high-pressure jet grouting pile, so as to better grasp the construction parameters and technological process and provide support for optimizing the design scheme. Secondly, the construction parameters of high-pressure jet grouting pile can be optimized, such as adjusting the ratio of curing agent, injection pressure and rotation speed, so as to obtain the optimal strength and stability of the pile. In addition, it is necessary to arrange the construction organization reasonably, optimize the construction sequence and the allocation of human resources, improve the construction efficiency and reduce the cost.

5. Comprehensive comparison and analysis of deep foundation pit excavation and support schemes

5.1 Introduction of Common Support Schemes

Some common support schemes are as follows: ① Steel sheet pile support: hot rolled steel sheet pile or cold-formed steel sheet pile is used as the main bearing structure, and continuous sheet wall is formed by driving into the ground to retain soil and prevent water. ② Row pile support: bored piles or precast piles are used as the main bearing structure, and a continuous supporting wall is formed through row arrangement to retain soil and prevent water. ③ Soil nailing wall support: through drilling, inserting steel bars, grouting and other processes, steel bars and soil are combined to form reinforced soil, and then concrete is sprayed to form soil nailing wall for retaining soil and waterproofing. ④ Diaphragm wall support: Excavator or manual excavation is used to pour reinforced concrete to form the diaphragm wall to bear the soil pressure and groundwater pressure.

5.2 Comparison between high-pressure jet grouting pile and common support schemes

This section will discuss the differences between high-pressure jet grouting pile and common support schemes from the aspects of application scope, construction technology, waterproof performance and economy. See Table 1 for details.

Table 1: Comparison between high-pressure jet grouting pile and common support schemes

Characteristic	High pressure jet grouting pile	Steel sheet piles and row piles
Area of application	Deep foundation pit excavation and support engineering under various soil conditions is especially suitable for complex geological conditions such as soft soil foundation and sandy soil foundation.	Geological conditions such as general cohesive soil and sandy soil.
Construction technology	Relatively simple, the pile can be formed only by drilling and spraying curing agent.	It is complicated and needs mechanical equipment such as pile driver and drilling machine.
Waterproof	Good, the curing agent can quickly harden after mixing with soil to form a continuous pile, which effectively prevents groundwater infiltration.	Relatively poor, need to set waterproof layer at the bottom.
Economy	Under the same conditions, the construction cost is lower, because the construction speed is fast, the equipment is simple and the material cost is low.	The construction cost is high because of the need to use large mechanical equipment and steel.

The above table briefly presents the key differences between high-pressure jet grouting pile and other supporting schemes.

5.3 Advantages of high-pressure jet grouting pile support scheme

This section will discuss the advantages of high-pressure jet grouting pile support scheme from the aspects of application scope, construction technology and economy. See Table 2 for details.

Table 2: Advantages of high-pressure jet grouting pile support scheme

Characteristic	Describe
Wide application range	High-pressure jet grouting pile is suitable for all kinds of soil conditions and complex geological conditions, and can deal with a variety of deep foundation pit excavation and support problems.
Simple construction technology	The construction technology of high-pressure jet grouting pile is relatively simple, easy to operate, and has low requirements for equipment, which can shorten the construction period.
Good waterproof performance	High-pressure jet grouting pile has good waterproof performance, which can effectively prevent groundwater infiltration and ensure the dry environment during deep foundation pit excavation.
Better economy.	Compared with other supporting schemes, the construction cost of high-pressure jet grouting pile is lower and it has better economic benefits.

The above table reflects the advantages of high-pressure jet grouting pile support scheme.

6. Conclusions

High-pressure jet grouting pile is a technology widely used in deep foundation pit excavation and support scheme. Compared with other common support schemes such as steel sheet pile, row pile and soil nailing wall, high-pressure jet grouting pile has wider application scope, simpler construction

technology, better waterproof performance and better economic benefits. First of all, the high-pressure jet grouting pile is suitable for all kinds of soil conditions and complex geological conditions, and can deal with a variety of deep foundation pit excavation and support problems. Whether it is soft soil foundation, sandy soil foundation or other complex geological conditions, high-pressure jet grouting pile can provide effective support solutions. Secondly, the construction technology of high-pressure jet grouting pile is relatively simple, and the pile body can be formed only by drilling and spraying curing agent. In addition, high-pressure jet grouting pile has good waterproof performance, and the curing agent can quickly harden after mixing with soil to form a continuous pile body, which effectively prevents groundwater infiltration. This makes the high-pressure jet grouting pile play an excellent supporting effect in areas with high groundwater level or complicated hydrological conditions. Finally, the construction cost of high-pressure jet grouting pile is lower because of its fast construction speed, simple equipment and low material cost. Therefore, the high-pressure jet grouting pile technology has important application value in the excavation and support scheme of deep foundation pit around the original natural foundation.

In the future research, it is suggested to further explore the optimal design of high-pressure jet grouting pile technology and the improvement of construction technology, so as to better meet the needs of different engineering conditions and improve the supporting effect and engineering safety. At the same time, we should also pay attention to the research on the sustainability and environmental protection of high-pressure jet grouting pile technology in order to realize the sustainable development of engineering construction.

References

- [1] Jin Gaoming, Zhang Haigang. *The application of water-stop curtain of cast-in-place pile and high-pressure jet grouting pile in deep foundation pit support in complex geology [J]. China Building Materials Science and Technology*, 2021, 30(6):3.
- [2] Feng Xiangying. *Application of high-pressure jet grouting pile waterproof curtain in deep foundation pit support [J]. Heilongjiang Science and Technology Information*, 2020, 000(026):143-144.
- [3] Lin C, Yang C. *Application of Bored Pile and High Pressure Rotary Jet Grouting Pile in Deep Foundation Pit Support Project of Rainwater Pumping Station in Central Urban Area [J]. Construction & Design for Engineering*, 2019.
- [4] Dun Haishan. *Application of high-pressure jet grouting pile waterproof curtain in deep foundation pit support [J]. Architectural Engineering and Management*, 2020, 002(008):P. 60-62.
- [5] Shi Yufeng. *Application of controlled cement curtain grouting and high-pressure jet grouting pile technology in deep foundation pit excavation of nuclear power [J]. Real Estate Guide*, 2019, 000(008):142, 205.
- [6] Zhu Xingwang, Shi Jingge, Li Chunxiu. *Application of high-pressure jet grouting pile in foundation treatment of deep foundation pit [J]. Geotechnical Foundation*, 2022(002):036.
- [7] Ran Liyuan. *Construction Technology of Deep Foundation Pit Support in Architectural Engineering Construction [J]. Architectural Technology Research*, 2023, 6(2):85-87.
- [8] Wang Kai. *Design of Temporary Deep Foundation Pit Support Scheme for Linjiang Pumping Station Project [J]. Water Conservancy Technical Supervision*, 2022(11):253-255.
- [9] Liang Xueyuan. *Analysis of technological test pile of high-pressure jet grouting pile supporting a deep foundation pit [J]. Guangdong Civil and Architecture*, 2020, 27(9):3.
- [10] Yuan Xiaoyuan, Si Lijing, Wang Zikai. *Application of bored piles and high-pressure jet grouting piles in urban river deep foundation pit support [J]. Water Conservancy Construction and Management*, 2020, 40(12):5.
- [11] Chen Wang, Li Zongkai, Li Guiying, et al. *Construction technology of high-speed rail viaduct passing through soft soil deep foundation pit under construction [J]. Transportation Technology*, 2023, 12(5):7.