Intelligent Construction Technique of Pile Foundation Engineering with Slurry Wall Protection

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Abstract. In the era of knowledge-based economy, innovation is ubiquitous and new technologies emerge in an endless stream. Many traditional construction techniques with inherent deficiency has been gradually replaced by new ones. On account of current construction of pile foundation engineering with slurry wall protection, slurry is manually replenished and slurry indexes are repeatedly measured by manual work, which affects the construction schedule and keeps security risks. This thesis proposes a new technique, in which slurry pressure variation values replace the specific gravity changes and linkage with slurry pump is utilized, which achieves automatic replenishing of slurry in pile foundation construction and realizes intelligent construction of pipe foundation engineering with slurry wall protection.

Introduction
At the present stage, artificial intelligence has become the development strategy of many countries around the world, we are no exception. Our country gives great impetus to development of artificial intelligence. Artificial intelligence integrates with urban development, resulting in the development of intelligent city. Artificial intelligence integrates with urban construction, realizing intelligent construction. General Secretary Xi indicates in the New Year message of 2019 that made in China, created in China and built in China would continue to change Chinese outlook. Great changes are taking place in our lives. With starting of the project “Built in China 2035”, urban construction would open a new page. On the basis of Internet of Things, Cloud Computing, Mobile Internet Technology and intelligent device, intelligent construction technology would subversively change the traditional construction technique in the future.

With rapid development of economy, accelerating urbanization and quick rising of construction industry, more and more buildings are constructed in complex geology thus leading pile foundation engineering to become one of the most commonly used methods in construction. Aiming at complex foundations like weak foundation or block stone foundation, dry process to create pore usually produces accidents of collapsing hole, sticking drill, burying drill, etc. For the purpose of guaranteeing safety construction, slurry wall protection pore-creating construction technology would be utilized. The existing slurry replenishment mostly relies on manually testing slurry indexes and manually starting slurry pump to provide drill hole with slurry, which wastes human resources, increases cost and does not master slurry indexes in real time, thereby having certain risk of collapsing hole.

Intelligent Construction Technique Principles of Pile Foundation Engineering with Slurry Wall Protection

Problems of Existing Technology in Pile Foundation Construction with Slurry Wall Protection
At this stage, pile foundation engineering construction mostly adopts mechanical pore-creating processes of rotary drilling rig, percussion drilling rig, flushing drilling rig and whirling driller, among which rotary drilling rig is widely utilized because of the advantage of quick pore-creating speed. While encountering unfavorable geology, dry-boring method of this technology is so
restricted that construction technique of pile foundation with slurry wall protection would be applied to pile foundation construction of special geology for the purpose of guaranteeing security and stability of pore wall. The existing pile foundation construction technology has the following disadvantages.

① Pile foundation drilling slurry indexes could not be monitored in real time in which slurry is manually replenished. Pile foundation with slurry wall protection utilizes professional equipment to do mixing. In pile foundation construction, slurry mixing circulating pool would be arranged in construction site, in which slurry is drawn from slurry pit and poured into drill. During pile foundation construction, professionals are arranged in charge of testing indexes of slurry’s specific gravity. According to requirements, slurry pump would be manually operated to pump slurry into drill. This process may be greatly influenced by human factors in which specific gravity indexes could not be monitored in real time and slurry replenishment may be not in time thus resulting in pore collapsing accidents and keeping certain hidden dangers.

② Slurry control requires professionals so that engineering cost increases. During site operation, multiple mechanical devices synchronously run. For the sake of testing slurry in dexes in time, several professionals are needed at the same time to do slurry testing.

**Intelligent Construction Technique Principle of Pile Foundation**

① In the construction of pile foundation engineering with slurry wall protection, slurry indexes mainly include specific gravity, viscosity, sand factor, colloid rate and PH value. Drilling slurry indexes in intelligent construction technique of pile foundation with slurry wall protection take liquid slurry pressure in the drilling hole as standard of controlling slurry replenishment. Install pressure sensor in drill steel casing and preset slurry pressure control index. When slurry pressure is less than the preset value, linkage slurry pump replenishes slurry into drilling hole.

![Pressure sensor](image1.png)  ![Comparison graph between slurry pressure and specific gravity](image2.png)

② **Comparative Test between Slurry Specific Gravity and Pressure**: Install pressure sensor in the middle position of steel casing in drilling mouth which keeps 1m far from liquid level of slurry. Measure the corresponding values between slurry specific gravity and pressure thus fitting comparison graph between specific gravity and pressure of slurry. During the process of pile foundation drilling construction, choose corresponding slurry specific gravity according to different geological conditions and correspondingly choose pressure indexes so as to determine the preset slurry control standard in which pressure sensor keeps linkage with slurry pump. When slurry pressure is monitored to be less than the preset value, slurry pump automatically starts to pour slurry into drilling hole. While pressure in drilling hole is bigger than the preset value, slurry pump automatically closes and stops grouting. Fig. 1 shows pressure sensor. Fig.2 is comparison graph between slurry pressure and specific gravity.

**Application Range of This Technique**

This technique not only applies to pile foundation engineering construction in weak geological conditions of clayey soil, floury soil, sandy soil, mucky soil and manual backfill but also goes for
This technique is suitable for the pile foundation engineering with different pile diameters and lengths, especially for pile foundation with big diameter and deep hole.

This technique is appropriate for the pile foundation engineering construction with slurry wall protection which utilizes different drilling rigs to finish boring such as rotary drilling rig, percussion drilling rig, flushing drilling rig, etc.

Intelligent Construction Technical Protocol of Pile Foundation with Slurry wall Protection

Construction Technology Process

Construction Preparation

① Staff Management: Carry on training to constructors with occupational safety, technical capacity and operating skills, thus leading them to acquire relevant vocational and technical qualification certificates.

② Leveling Site: Level the operation site and guarantee drilling rig to be in place.

③ Measuring and Paying-off: After leveling site: measure and position the pile foundation pore site and arrange control pile in pile hole to benefit subsequent pile foundation construction.

④ Drilling Rig Entering Site: Determine the number and time of drilling rig entering the site according to the type of drilling rig, its model and construction schedule. Mechanical equipment in the site keeps common test run and is all set.

⑤ Slurry Pit Construction: Set up slurry pit and corresponding circular ditch in construction site in order to gather the extracted slurry and prepare slurry.

Construction Technology

① Burying Steel Casing: Utilize drilling rig to drill the hole till burying depth and install pile casing which should align the pore site. Backfill clay around pile casing and tamp in layers. Pile casing is produced by 0.9mm thickness of steel plate whose inner diameter is 200mm bigger than pile diameter and length is no less than 3.0m. Trepan on the pile casing wall whose position
is 1.5m away from the surface. Weld dedicated box and install pressure sensor in it. Lay sensor’s power and signal cables along the pore wall, which is linked with ground receiver and slurry pump. After burying pile casing, top surface would be 300mm away from ground. Pile casing length caters for the condition that slurry level in the hole should be more than 2.0 m away from pile casing bottom to avoid slurry flushing pile casing bottom soil during lifting drill process or avoid slurry surface being lower than groundwater level thus resulting in negative pressure and hole collapsing. Set grout vent on the top of pile casing to facilitate slurry circulation. Vertical curve of pile casing center should coincide with center line of pile whose plane position’s allowable deviation should be within 5cm and gradient deviation should be not more than 1%.

Start Drilling: After installing pile casing and before drilling, pump slurry into drill by manual work. When drilling depth is 5m away from pore mouth, open the pressure sensor to monitor changing conditions of slurry pressure in real time and automatically replenish slurry into drill hole thereby guaranteeing quantity and quality of slurry protecting wall during drilling process. The beginning of drilling should remain steady in which drilling rig and footage keep low speed so as to avoid deflection of pore site.

Drilling Construction:

a. During drilling construction process, timely replace the worn drill which exceeding standard and accurately choose the drill type according to soil layer changing conditions.

b. During drilling process, control drilling footage speed according to geological conditions. From hard stratum to soft stratum, properly quicken drilling speed. On the contrary, drilling speed should keep slow.

c. Control the slurry indexes during drilling process. Besides monitoring slurry pressure, indexes of sand factor and viscosity of slurry should be measured, thus accurately determining slurry conditions in pile hole. After drilling and lifting, slurry level in the hole should be more than 2.0m higher than pile casing bottom and over 1.0m higher than underground water level.

d. Specific gravity of slurry protecting wall is from 1.1 to 1.3, which would be properly selected according to different geological conditions and different types of drilling rig. Viscosity of common stratum should be from 16s to 22s. Viscosity of loose stratum should be from 19s to 28s. Sand factor is not more than 4%. Colloid fraction is not less than 95%. PH value is bigger than 6.5.

Finishing Drilling Hole:

a. Check and clean drilling hole when its depth reaches the required value, in which hole depth, hole diameter, hole site and hole shape have to be examined. Cleaning hole utilizes the method of taking out slag or slurry replacement method.

b. Cleaning standards should cater for design specification requirements, in which there exist no discharged slurry particles with thickness from 2mm to 3mm by hand touching. Specific gravity of slurry within 500mm of pore bottom should be less than 1.25, whose sand factor is not more than 8% and viscosity is bigger than 28s. Before pouring underwater concrete, keeps the sediment thickness at pore bottom being not more than 20cm.

Fabrication and Installation of Steel Reinforcement Cage of Pile Shaft: Material, processing, joint and installation of steel reinforcement cage meet the requirements. Protective layer of steel reinforcement framework utilizes mortar pad. Each streak of mortar pad would be vertically set every other 2m and each streak includes six mortar pads along the circumference.

Concrete Pouring of Pile Shaft: Pile shaft concrete utilizes underwater concreting technology.

Intelligent Construction Technique practice of Pile Foundation with Slurry Wall Protection

One project is composed of multi-layer and high-rise buildings. It includes 24 blocks of building and 150 thousand square meters of total covered area. This engineering project south meets Fujiang River, north depends on Flower and Fruit Mountain, east links with residential area under construction and west adjoins artificial lake on campus. Engineering construction site originally
belongs to old channel area, which is recently back filled to become construction site. From top to bottom, engineering geology is divided into silty backfill soil layer from 0m to 20m, clay layer from 8m to 20m, pebble layer from 14m to 40m, sludge layer from 40m to 43m, intense weathering shale layer from 43m to 46m and moderate weathering shale layer from 46m to 50m. Except for 1st to 7th and 19th to 23rd buildings, all the others are mechanically bored cast-in-place pile foundations. On average, there are 65 pile foundations of each block of building, whose diameter is from 1.0m to 2.4m and length from 20m to 50m. Moderate weathering shale layer is supporting layer. The position -6m away from construction site is water line and pile foundation applies underwater operation, where geology is so complex that pile foundation construction keeps great difficulty and has serious collapsing risk. According to the specific geological conditions of this project, this thesis utilizes intelligent construction technique of pile foundation with slurry wall protection and rotary pile construction technique of separation regeneration circulation slurry wall protection. Pile foundation engineering started in July 2013 and completed in December 2015, which acquires good economic and social benefit.

Conclusions

In the intelligent construction technique of pile foundation engineering with slurry wall protection, slurry specific gravity is concerned with pressure relation curve and burying depth of pressure sensor. Before specific engineering construction, slurry specific gravity and pressure relation curve should be corrected. Realize real-time monitoring on pile foundation drilling slurry and automatic replenishment thus achieving intelligent replenishment construction through monitoring slurry pressure instead of specific gravity indexes and setting automatic opening and closing slurry pump which links with pressure sensor. This technique reduces labor costs from professionals for slurry testing during pile foundation construction. It also reduces drilling pause resulting from slurry testing, which increases drilling efficiency. It provides certain references for similar projects.

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