

Research on Construction Technology of First Pile in an Urban Expressway under Complicated Conditions

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Abstract: This paper develops a research method on the construction of the first pile in the process of the construction on an urban expressway under complicated conditions, such as the difference between the underground conditions and the exploration results, the sand formation, the whole weathered and the rich groundwater. We study the relevant technical parameters and construction organization through construction of the first pile. The results show that construction on the first pile is very important under complicated conditions and can provide a basis to continuously improve the level of the whole pile foundation construction technology, and ultimately determine the entire project feasible construction program and the successful completion of the construction project.

1. Introduction

Construction of piles in single or two complex conditions is often discussed^[1-3], however construction of pile under more than two adverse conditions is relatively small. A coastal urban expressway project, including a viaduct, the total length is about 5.138km. Two high-voltage, commercial land and residential land-based are along the urban expressway, the construction environment is very complex. The total length of the viaduct is 4151.8m. A relief road 6-lane dual carriageway is under the viaduct. The main line adopts the first-class highway standard, the design speed is 80km / h, the auxiliary road adopts the urban trunk road standard, the design speed is 50km / h; the u-turn ramp adopts the urban secondary road standard, the design speed is 40km / h; the design speed of up and down ramp on the main line is 40km/h.

The foundation of the site consists of artificial soil layer, siltation layer, residual soil layer and weathered bedrock. The quaternary soil layer is composed of silty clay, silt soil and saturated sand and so on. The bedrock is divided into four rock zones: all weathered, strong weathering, partial weathering and weak weathered rock. The degree of weathering is quite different, local hard and soft folder, part of the sand or full weathering. According to the project, the foundation of the project pile is mainly the bridge pile foundation. The foundation is the pile foundation of the reinforced concrete pouring pile. The foundation of this project has 782 piles, including: 43 ϕ 1.3m, 208 ϕ 1.6m, 364 ϕ 1.8m, 39 root ϕ 2.0m; design pile length 21m ~ 68m, pile foundation with friction pile and rock-socketed pile. According to the requirements of concrete durability combined with different environmental role level, pile concrete uses two strength grades: C30 and C35.

2. Pile foundation construction plan

2.1 Parameters of the first pile

In order to verify the drilling process determined by the construction of the bored pile, the mechanical selection and guarantee the construction quality of the subsequent pile foundation in the case of rock formation, weathered, groundwater and so on, it is determined that Bridge KZ6 #, KZ9# and KZ7# piles for the first batch of bored piles construction project are selected according to the actual situation. The first piles are KZ6-1, KZ9-1 and KZ7-2.

Table1 Design parameters of the first pile foundation

No	Pile	Diameter (cm)	Length (m)	Design depth into the rock	lithology	Concret $\text{c}(\text{m}^3)$	Steel(Kg)
1	KZ6-1	180	57	4.55	weathered	147.59	7399
2	KZ7-2	180	54	4.44	Strong weathered	139.96	7179
3	KZ9-1	180	57	4.45	Partial weathered	147.59	7399

Note: KZ6-1 and KZ9-1 with rotary drilling into holes, KZ7-2 using rotary drill and impact drill into the hole.

2.2 Construction technology and sequence

Construction for the first piles mainly to verify the process and get parameters, all that could provide a reliable reference for the following construction. The following figure shows the construction process and inspection process determined by the first piles construction. The main construction process is as follows: construction preparation → construction survey → buried steel pipe caging protection → laying slurry circulation system → drilling machine in place → drilling → check hole → change slurry and clear hole → install steel cage, test tube and catheter → second time to clear hole → perfusion concrete. According to the construction plan, the main construction methods used in the project are summarized, and the main parameters of the construction project are as follows:

1) Setting out Survey

The pile center coordinate is obtained by using the total station for embedment of tube for pile protection facilities. Tube for pile protection facilities laid requirements: tubes are embedded according to the size of the pile diameter. Steel caging is made of A3 steel plate with thickness of 10mm, The diameter of the steel caging is 2.0m and the bottom of the caging passed the silt layer to ensure the construction quality of the pile foundation and ensure the 2.5m depth for the steel cage which is 0.3m higher than the top surface of the platform (Table 2 for detailed parameters of steel cage).

Table 2 detailed parameters of steel cage

No.	Diameter (cm)	Length (m)	Design depth of pile top (m)	Elevation of pile tip (m)	Elevation Guard of roof (m)	Design depth of pile top (m)	Depth of the tube(m)	Center deviation(cm)
KZ6-1	180	57	0.8	-56.2	4.476	60.676	3.69	1
KZ7-2	180	54	0.9	-53.1	4.468	57.568	5.6	3
KZ9-1	180	57	1	-56	4.757	60.757	5.6	1

2) Drilling into holes

In order to ensure the pressure in the construction process hole, preventing shrinkage, collapse, etc., we increased the proportion of slurry (slurry with clay soil pulp) and consistency in the construction process. It is found that the exploratory geological stratigraphic structure is basically consistent with the results of the advanced drilling through the holes record table which is measured and kept at regular intervals. However, the elevation and the layer thickness are different with geological stratigraphic structure exploration results.

3) End hole

In order to ensure the quality of holes, we use high-precision ultrasonic hole detection technology. The hole depth is measured by rope measuring method. We add 3 kg counterweight at the bottom of rope and check the length per meter with a ruler. The pile diameter is detected by using device for checking hole. the length of the hole is 11m, and the hole diameter is pile diameter. All specific data of piles are shown in Table 3, which meet the requirements.

Table 3 parameters of first piles

pile	Diameter (cm)	Design depth of pile top (m)	Design length (m)	Actual pile length (m)	Elevation of pile tip (m)	Design depth into the rock(m)	Actual elevation into the rock(m)	Actual depth into the rock (m)
KZ6-1	180	0.8	57	57.166	-51.65	4.55	-49.686	-6.68
KZ7-2	180	0.9	54	54.112	-48.66	4.44	-48.632	-4.58
KZ9-1	180	1	57	55.643	-51.55	4.45	-45.243	-9.4

4) Second clear hole

We put catheter into holes before perfusion. First, we give every catheter number, then we use the duct and sediment separator positive and negative circulation to clear the hole until the slurry meet the qualification(Including specific gravity is 1.03 ~ 1.1, sand rate of not more than 2%, viscosity between 17 to 22, sediment thickness of less than 2cm), finally, the hole meeting the requirements should be poured concrete(Table 4).

Table 4 parameters of slurry

Pile	Diameter	Design pile length	Actual pile length	Parameter before pouring		
	cm	m	m	Gravity of slurry	sand rate	viscosity
KZ6-1	180	57	57.166	1.09	0.5	17
KZ7-2	180	54	54.112	1.08	1.15	20
KZ9-1	180	57	55.643	1.07	1.3	22

5) Infusion of underwater concrete

Ready-mixed concrete come the mixing station which is 3km from project department. The test records are shown in Table 5.

Table 5 concrete test parameters

Concrete test record									
Materials	Theoretical mix(kg/m ³)							Design the measured slump(mm)	
	Cement	Flash fly	Fine aggregate	5-10mm Coarse aggregate	10-20mm Coarse aggregate	Admixture	Water		
	Foshan Conch	Guangzhou Yunhong	River sand	Zengcheng Geely	Zengcheng Geely	Guangdong strong Shi	Tap water		
Theoretic al value	329	74	773	103	922	4.43	149	180-220	
Materials	Construction mix ratio(kg/m ³)							Measured slump of the first set(mm)	
	Cement	Flash fly	Fine aggregate	5-10mm Coarse aggregate	10-20mm Coarse aggregate	Admixture	Water		
	Foshan Conch	Guangzhou Yunhong	River sand	Zengcheng Geely	Zengcheng Geely	Guangdong strong Shi	Tap water	Mixing station	On site
KZ6-1	329	74	797	103	922	4.43	125	200	195
KZ7-2	329	74	805	103	922	4.43	117	210	200
KZ9-1	329	74	798	103	922	4.43	124	200	200

From the experimental record, it can be found that the quality control of pile foundation concrete is good and the slump loss is small, which is beneficial to the quality control of pile foundation perfusion, including protection measures for perfusion completion, time for pulling out, detection for the sound tube and the protection of the orifice.

3 Problems and solutions

3.1 Problems

1) Crane position is not appropriate in the steel cage hoisting process and hoisting is not standardized because of the narrow construction site, all these result the time is too long for hoisting cage. Clear hole time is too long because of the use of clay pulp and the slurry performance is insufficient resulting collapse or shrinkage is easy in the hole.

2) Partial rock formation strength is higher than exploration results leading to drilling speed is limited and drill is advanced into the rock because geological survey and the actual drilling pile is different. Time for rotary drilling the upper part of KZ6-1 is 2 days and time for rotary drilling the holding layer is 6 days to reach design elevation; However, time for rotary drilling the upper part of KZ9-1 is 2 days and time for rotary drilling the holding layer is 10 days. Depth into the rock for KZ6-1 is 6.68m, depth into the rock for KZ7- 2 is 4.58m, depth into the rock for KZ9- 1 is 9.4m.

3) Through the construction of the first pile, it is found that the rock-bearing pile of the project is granite, the rock strength is high and the integrity is good. However, the upper layer is sand layer, the whole weathered and strong weathered granite (easily disintegrated in water), which lead it is easy to occur accidents in the hole and adverse to the quality of piles. At the same time, we found the hole expanding rate is little when pouring concrete.

Table 6 concrete construction statistics of first pile

NO.	Pile	Diame ter (cm)	Design pile length (m)	Actual pile length (m)	Theoretical value of concrete (m ³)	Actual value of concrete (m ³)	Surplu s(+%)	Rem arks
1	KZ6-1	180	57	57.166	145.47	151	3.8	
2	KZ7-2	180	54	54.112	137.70	145	5.3	
3	KZ9-1	180	57	55.643	143.9	144	0.1	

Table 6 shows that surplus for the first pile is happen when construction. Then we analysed the result for the KZ6-1, KZ7-1 and KZ9-1 (Table 6). Through the comparison of concrete construction, it is found that the suspicious shrinkage area is full weathering and strong weathered layer. The layer is full of weathering and strong weathered granite (grayish yellow, kaolin and clay), and it can be soften and disintegrated in water.

3.2 Solutions

1) Reasonable adjustment process, simplify the inspection and other processes, shorten time for hole cleaning, steel cage installation and pouring concrete should be adopted. At the same time, parameters for first pile should be executed strictly. Shorten the time for cleaning hole and steel installation through the rational organization of construction and improving construction efficiency in the next pile construction. In order to facilitate the pile into the rock and the final hole to determine, the following pile construction as far as start from the foundation having the first construction in the case of conditions permitting.

2) Strengthen the slurry quality control. The slurry performance indicators should be controlled for the construction of pile foundation using clay slurry, especially in the processing of second hole cleaning, steel cage installation after the hole is completed. It is proposed that increment in the appropriate proportion of slurry and consistency to ensure the hole pressure to prevent shrinkage and collapse hole to solve the matter of thick sand layer, full weathering and strong weathered, soften and disintegrated in water, all that are caused by the special geological characteristics.

3) It is recommended to introduce advanced high-precision ultrasonic hole detection technology to ensure the quality of the hole, and shorten the time between hole forming and pouring concrete to reduce the risk of collapse and shrinkage.

4) For the construction of the subsequent pile foundation, the friction pile may be considered to use the rotary bored pile because of its good drilling speed. The rock-socketed pile construction is appropriate to use the combination of the rotary drilling rig and the percussive drilling, at the same time, the drill diameter should be strictly controlled including less than pile diameter and 1cm-2cm more than the designed pile diameter before the construction.

4. Conclusions

This paper discuss that the relevant construction technical parameters are obtained by construction of the first pile, which can provide a reference for improving the construction technology of the whole pile foundation and ensure to complete the project construction successfully. The following conclusions emerge:

1) The quality assurance measures of pile position can be made to ensure the construction quality of bored piles. By means of slow drilling measures and other measures to ensure the drilling verticality. Shrinkage and collapse are prevented through reasonable drill bit structure and drilling technical parameters, the clay pulping and increase the proportion of slurry and consistency.

2) The technical staff should be familiar with the geological exploration data, data in the drilling process should be recorded in real time. sweeping holes, circulation cleaning, slurry circulation and other measures to ensure that bottom of bore have no overfull residue to ensure the hole quality according to record the situation when pile drilling arrived at the design hole depth.

3) Protective layer block for reinforcing steel used concrete block, reserved hole in the middle for binding, of 4.5cm thickness and 15cm diameter. Protective layer area is set every 2m and 4 concrete blocks every area. Quality tracking system for concrete is established and the laboratory can check the mixture of raw materials, mud content, particle size and strength at any time. All these are mainly to ensure the quality of steel cage and concrete.

4) In order to ensure the quality of piles, all piles of this project are detected using ultrasonic. And concrete core pulling test method is adopted according to 1% of the frequency of random, at the same time, concrete core pulling test is used on KZ6-1; the results show the piles arrived at the design requirement and ensure the quality of piles.

References:

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