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Analysis on Foundation Treatment Process and Engineering Visa Scheme of Special Karst Stratum

Xunhua Yin[1, *]

[1] *School of Civil Engineering and Architecture，University of Jinan, China*
[*] *Corresponding author*

ABSTRACT. *Bored pile foundation treatment is an effective method for soft soil treatment of medium and high-rise residential buildings, structures, ports and wharves. This paper mainly discusses the reasons why the pouring concrete volume far higher than the design value when bored piles are selected for foundation treatment under special karst geological conditions by combining with geological survey, drawing design, pile foundation investigation and site construction.Thus choose the best project visa processing program.*

KEYWORDS: *bored pile, karst geology, design value, Engineering visa*

1. Introduction

In recent years, with the rapid development of China's economy, infrastructure construction and real estate have become the pillar industries of China's national economy. Although the state has recently issued relevant policies to reduce the proportion of land finance in government revenue to stimulate the development of manufacturing industry, the real estate industry will still be one of the important components of the national economy in the future.With the rapid development of high-rise and super high-rise buildings, bored piles are widely used in the reinforcement of soft foundation with deep bearing stratum due to its economy and reliability.However, under special geological conditions, the volume of concrete injection of bored pile is far greater than the design volume, which is often ignored in construction and cost control.

2. Project overview

The project is a real estate development project of a plot in Luneng Lingxiu City, Jinan. It is located in the south of the Second Ring Road South, with a total planned building area of 70204.69 m2, including residential, residential apartments,

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underground garage and corresponding supporting facilities.Among them, residential and residential apartments are shear wall structures. Nine of the 12 residential buildings in the project are reinforced with bored piles, which are 1, 2, 3, 4, 5, 6, 8, 10 and 12.The remaining 7, 9 and 11 are treated by manual and mechanical layered compaction.

3. Basic theory of foundation reinforcement

3.1 Summary of foundation problems in Civil Engineering

(1) Strength and stability.

(2) Compression and uneven settlement.

(3) When the leakage of the foundation exceeds the allowable value, water loss will occur, resulting in accidents.

(4) Dynamic loads such as earthquake, vibration of machines and vehicles, wave action and blasting may cause liquefaction, instability and seismic subsidence of foundation soil, especially saturated cohesionless soil.

3.2 Basic methods and applicability of foundation treatment

3.2.1 Replacement foundation method.

The replacement and filling method is to excavate the soft soil layer within a certain range below the foundation bottom surface, and then backfill the materials with high strength, low compressibility and no erosivity, such as medium coarse sand, gravel or pebble, lime soil, plain soil, stone chips, slag, etc., and then tamp them in layers as the bearing layer of the foundation.

3.2.2 Geosynthetics foundation.

Geotextile foundation, also known as geopolymer foundation, is embedded in soft foundation or slope as reinforcement to form elastic composite soil under the joint action, so as to achieve the purpose of drainage, filtration, isolation, reinforcement and reinforcement, so as to improve the bearing capacity of soil, reduce settlement and increase the stability of foundation.

The reinforced soil foundation consists of three parts: fill, band reinforcement (or tie bar) and vertical wall panel.

3.2.3 Tamping foundation method

The heavy hammer compaction method is suitable for the slightly wet clay, sand, collapsible loess, miscellaneous fill and layered fill which is 0.8m above the ground. However, it should not be used when there is soft clay layer in the effective compaction depth.

Dynamic compaction is one of the most common and economical deep foundation treatment methods in China.It is suitable for the treatment of gravel soil,

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sandy soil, low saturation silt, cohesive soil, collapsible loess, high fill, miscellaneous fill, and "reclamation of land from the sea" foundation, industrial waste residue, garbage foundation, etc.It can also be used to prevent the liquefaction of silt and silt, and eliminate or reduce the collapsibility grade of macroporous soil.For high saturation silt, soft clay, peat and swamp soil, if certain technical measures are taken, they can also be used for underwater compaction.It shall not be used for foundation reinforcement that does not allow certain vibration impact on buildings and equipment around the project.The range of dynamic compaction treatment should be larger than the scope of building foundation. The width of each side beyond the outer edge of the foundation should be 1 / 2 ~ 2 / 3 of the design treatment depth under the base, and should not be less than 3m.

3.2.4 Preloading Foundation

Preloading foundation, also known as drainage consolidation foundation, is a kind of soft soil foundation reinforcement method, which completes soil consolidation settlement in advance and gradually increases foundation strength.It is suitable for the treatment of roads, warehouses, tanks, aircraft runways, ports and other large areas of muddy soil, silt and fill and other saturated cohesive soil foundation.Preloading is the key problem.

3.2.5 Vibrating Foundation Method

Vibroflotation foundation is also called vibration water flushing method. Under the joint action of vibration and flushing, the vibrator is sunk to a predetermined depth in the soil. After the hole is cleaned, gravel is filled into the hole section by section from the ground to the hole, or no filler is added, so that the foundation is compacted under the action of vibration. After reaching the required compactness, the vibrator can be lifted. In this way, the filling and vibration compaction are repeated until the ground, forming a large size in the foundationIt is a fast, economic and effective reinforcement method to improve the bearing capacity of the foundation and reduce the settlement and uneven settlement.

3.2.6 Sand pile, gravel pile and cement fly ash gravel pile

(1) Gravel pile and sand pile

Gravel pile and sand pile are called coarse-grained soil pile.It refers to forming holes in soft foundation by vibration, impact or vibration water flushing, and then squeezing gravel or sand into the hole to form a large-diameter dense pile composed of gravel or sand, which has the reinforcement functions of compaction, replacement, drainage, cushion and reinforcement.

Cement fly ash gravel pile (CFG pile)

The bearing capacity comes from the friction resistance and the bearing capacity of the pile end. The longer the pile is, the higher the bearing capacity is. The bearing capacity of the composite foundation formed by pile-soil can be increased by more than 4 times and the deformation is small. It is suitable for the foundation of multi-storey and high-rise buildings.

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In the process of implementation of this method, it is generally necessary to set up a cushion layer combined with the pile to ensure that the soil and the pile bear the load together.

3.2.7 Soil pile and lime soil pile method

It is mainly suitable for the treatment of collapsible loess or artificial fill foundation with a depth of 5-15m above the groundwater level.

However, the soil below the groundwater level or with water content more than 25% should not be used.

3.2.8 Deep mixing pile foundation

The deep mixing method is suitable for the reinforcement of muddy soil, clay and silty clay of various causes. It is used to increase the bearing capacity of soft soil foundation, reduce the settlement, improve the stability of slope and the water retaining curtain in the construction of various pit and trench projects.

3.2.9 Pile expanding method with column hammer

The pile is suitable for the treatment of miscellaneous fill, silt, cohesive soil, plain fill, loess and other foundations. Its applicability should be determined by field test in saturated soft soil layer below the groundwater level.The depth of foundation treatment should not exceed 6m, and the characteristic value of bearing capacity of composite foundation should not exceed 160kpa.The pile materials can be broken brick concrete, graded sand and gravel, slag, lime soil, cement mixed soil, etc.Each pile hole shall be tamped to at least 0.5m above the design elevation of pile top, and the upper pile hole shall be tamped and sealed with original trench soil.

3.2.10 High pressure jet grouting pile

High pressure jet grouting method is suitable for the treatment of silt, muddy soil, flowing plastic, soft plastic or plastic cohesive soil, silt, sand, loess, plain fill and gravel soil.

High pressure jet grouting method is divided into three categories: rotary jet grouting, fixed jet grouting and swing grouting.Single pipe method, double pipe method, triple pipe method and multiple pipe method can be used in construction.

4. Project case analysis

4.1 Geological Survey

The main purpose of geological survey is to evaluate the stability and bearing capacity of foundation, find out whether there are geological factors threatening the safety of the proposed project, and provide necessary geological parameters for the design unit.Without geological exploration, the design unit can not carry out engineering design.Through geological survey, the most reasonable foundation engineering scheme can be selected, which can save a lot of unnecessary investment for the construction party.According to the geotechnical investigation report of the

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project, the pile foundation design grades for the buildings number of 1, 2, 3, 4, 5, 6, 8, 10 and 12 are all grade A.

4.2 Engineering design

Engineering design refers to the design unit according to the developer's requirements for building type, residential location, single square cost, etc., combined with geological survey data to carry out architectural design, structural design, etc.Design stage is the key link of construction project cost control. Excellent design scheme can not only make residents have comfortable living experience, but also can reasonably save construction cost.

In this project, bored pile and dynamic compaction foundation are used for foundation reinforcement.The design diameter of bored pile is all φ 600, and the characteristic value of compressive bearing capacity of pile foundation is 2200KN.The design of dynamic compaction method requires that the bearing capacity of plain soil after dynamic compaction is 140 kPa.

Table 1 Design parameter table of proposed buildings

Building name	Number of floors above ground	Number of underground floors	Foundation type	Pile diameter (mm)	Number of piles	Vertical bearing capacity of single pile Characteristic value (KN)
1#	11	2	pile foundation	600	73	2200
3#	11、9	2	pile foundation	600	91	2200
4#	9、11	2	pile foundation	600	94	2200
5#	11	2	pile foundation	600	53	2200
6#	9、11	2	pile foundation	600	94	2200
8#	10	2	pile foundation	600	50	2200
10#	11	2	pile foundation	600	49	2200
12#	11	2	pile foundation	600	51	2200
2#	9、11	2	pile foundation	600	73	2200

4.3 Pile foundation investigation

4.3.1 Survey requirements

In this survey, one pile and one hole survey scheme is adopted to find out the stratum distribution at each pile position and the rock within 5m depth under the pile

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tip.In order to provide a reliable basis for pile foundation construction, the position and length of pile end bearing layer of each pile are determined.

4.3.2 Layout of investigation work

According to the survey Commission and pile foundation design and construction drawings, the proposed project adopts bored pile with a pile diameter of 600mm. The foundation pile shall enter into the moderately weathered diorite of layer ⑤, the moderately weathered limestone of layer ⑥, and the moderately weathered argillaceous limestone of layer ⑥ - 2 at least 0.8m.The drilling location is the center of each pile location. According to the pile foundation positioning map provided by the owner, there are 8 buildings including 1, 3, 4, 5, 6, 8, 10 and 12. The exploration points are arranged pile by pile, with a total of 555 exploration points.

4.3.3 Investigation means

Engineering drilling method is adopted in this survey.12 xy-150 drilling rigs were used for field drilling.

4.3.4 Investigation results

According to the investigation and investigation, the unfavorable geological process of the site is mainly karstification.The field drilling shows that there are small dissolution holes and grooves in the side wall of the core, and the local core is half wall and honeycomb corrosion is obvious.Within the scope of drilling depth, there are karst caves developed or local corrosion is strong in the proposed building site. The karst caves are generally filled or partially filled with plastic hard plastic clay mixed with a small amount of karst limestone fragments, and a small amount of no filling materials.

4.3.5 Investigation and analysis

Due to the development of karst cave caused by underground karst process, the cement slurry should be hydraulically injected into the karst cave and fissure during the construction of pile foundation, so as to prevent the further development of karst cave and fissure from having adverse effect on the foundation stability.

4.4 Construction of bored pile

4.4.1 Construction method

The construction method of slurry wall protection is adopted in this project.The construction process is as follows: site leveling → mud preparation → casing embedding → working platform laying → drilling and positioning → drilling hole forming → hole cleaning and hole quality inspection → reinforcement cage lowering → underwater concrete pouring → casing pulling out → quality inspection.

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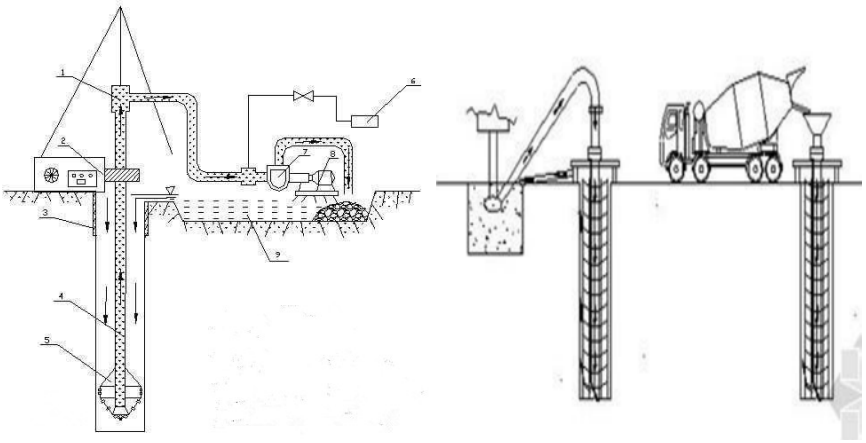

Figure. 1 Construction process diagram of bored pile

4.4.2 On-the-spot supervision

In the process of pouring concrete for bored piles, the supervisor shall supervise the construction quality on site by means of on-site supervision, so as to ensure that the pile foundation can be filled and compacted with sufficient pouring. The auditor shall also be on-site and record the concrete pouring volume of each truck of concrete tank truck.

4.5 Project visa analysis

According to the survey results of pile foundation, many karst caves have been produced by underground karst process. In order to prevent the underground karst caves and cracks from developing continuously and ensure that the bearing capacity of pile foundation will not be damaged, the concrete needs to be pressed into the underground karst cave and developed cracks when pouring concrete into bored pile, which greatly increases the amount of concrete used.

4.5.1 Measurement basis

(1) Quota basis

According to consumption quota of Construction Engineering in Shandong Province sc01-31-2016, the seventh item of cast-in-place pile foundation engineering in Chapter III is explained as follows:

The filling coefficient and material loss have been included in the material consumption of various cast-in-place piles, as shown in the table below.

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Table 2 Filling coefficient and material loss rate of cast-in-place pile

project name	Filling coefficient	Loss rate
Bored concrete pile with rotary drilling and percussion drilling machine	1.25	1%
Bored concrete pile with rotary and spiral drilling machine	1.2	1%
Cast in place concrete pile with pipe sinking machine	1.15	1%

My understanding of the above quota description is as follows:

① bored pile engineering shall be measured according to the volume of designed pile.

② The filling coefficient is the general ratio between the actual concrete volume and the designed concrete volume in the process of pile foundation pouring.During the construction process, cement concrete and its slurry will seep into the soil around the pile or in the small gap, resulting in the actual volume of concrete pouring greater than the design value. At the same time, the existence of filling coefficient is also a powerful guarantee for the pile hole to be fully injected with sufficient concrete to ensure the reliable quality of the pile body.

③ The loss rate refers to the loss ratio caused by various normal factors in the process of concrete transportation and pouring, which is the ratio of inevitable loss concrete volume to actual transportation volume.

(2) List basis

The volume of pile can be calculated according to the length of pile shown in the design drawing.

The volume of pile head can be calculated by volume according to the actual average length of pile head.

4.5.2 Pricing basis

Contract unit price: the construction general contract is a fixed unit price contract, in which the comprehensive unit price of pile foundation concrete is 936.96 yuan / m3.

4.5.3 Analysis of visa scheme

The description of some items in the norms of consumption quota and bill of quantities is not very clear. Therefore, for the readers of the specifications, when they stand on different positions, they will have different understanding of the same measurement specification. Therefore, engineering disputes often occur.First of all, we assume that the over injection volume is e, the actual volume is a, the pile head volume is t, the design volume is D, the filling coefficient is f, and the loss rate is R. the following is the analysis scheme to interpret the measurement specification from different angles.

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Scheme 1:

Building name	Unit of measurement	Actual quantities	Pile head volume	Design volume	Pouring volume	Excess injection volume (buckle pile head)	Comprehensive unit price (yuan)	Excess cost (yuan)
1#	m³	378.5	21.92	312.32	394.30	-15.80	936.96	
3#	m³	262	27.32	222.51	280.92	-18.92	936.96	
4#	m³	887.5	28.22	672.83	849.45	38.05	936.96	35653.32
5#	m³	274	15.91	199.45	251.81	22.19	936.96	20795.24
6#	m³	622.5	28.22	485.25	612.63	9.87	936.96	9249.55
8#	m³	397	15.01	301.53	380.68	16.32	936.96	15289.66
10#	m³	120	14.71	103.04	130.09	-10.09	936.96	
12#	m³	165	15.31	107.04	135.14	29.86	936.96	27979.50
2#	m³	488	21.92	369.16	466.06	21.94	936.96	20552.69
Subtotal						138.23		129519.96
Fees							6.56%	8496.51
Taxes							9%	12421.48
total								150437.95

The calculation formula of engineering quantity is as follows: e=A-D* f * (1 +R)

This scheme takes the building seat as the unit only considers the whole building concrete overfilled building seat does not consider the whole building concrete not overfilled building seat. But the project quantity of pile head is not deducted. The calculated volume of over poured concrete is 138.23m3, and the visa amount is 150437.95 yuan. It is beneficial for the construction enterprises but the cost of the owner is relatively large.

Scheme 2:

Building name	Unit of measurement	Actual quantities	Pile head volume	Design volume	Pouring volume	Excess injection volume (buckle pile head)	Comprehensive unit price (yuan)	Excess cost (yuan)
1#	m³	378.5	21.92	312.32	394.30	-37.72	936.96	
3#	m³	262	27.32	222.51	280.92	-46.24	936.96	
4#	m³	887.5	28.22	672.83	849.45	9.83	936.96	9210.42
5#	m³	274	15.91	199.45	251.81	6.28	936.96	5885.95
6#	m³	622.5	28.22	485.25	612.63	-18.35	936.96	-17193.35
8#	m³	397	15.01	301.53	380.68	1.31	936.96	1224.29
10#	m³	120	14.71	103.04	130.09	-24.80	936.96	
12#	m³	165	15.31	107.04	135.14	14.55	936.96	13632.82
2#	m³	488	21.92	369.16	466.06	0.02	936.96	17.24
Subtotal						13.64		12777.36
Fees							6.56%	838.19
Taxes							9%	1225.40
total								14840.96

The calculation formula of engineering quantity is as follows: e=A-D* f *(1+R)- T

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This scheme takes the building seat as the unit only considers the whole building concrete overfilled building seat does not consider the whole building concrete not overfilled building seat. , and the project quantity of pile head is deducted. The calculated volume of over poured concrete e is 13.64m3, and the visa amount is 14840.96 yuan. In this scheme, the building seat which over poured concrete is a unit, but the pile head volume needs to be deducted, so it is unfavorable to the construction unit and beneficial to the owner.

Scheme 3:

Building name	Unit of measurement	Actual quantities	Pile head volume	Design volume	Pouring volume	Excess injection volume (buckle pile head)	Comprehensive unit price (yuan)	Excess cost (yuan)
1#	m³	378.5	21.92	312.32	394.30	-15.80	936.96	-14807.72
3#	m³	262	27.32	222.51	280.92	-18.92	936.96	-17726.23
4#	m³	887.5	28.22	672.83	849.45	38.05	936.96	35653.32
5#	m³	274	15.91	199.45	251.81	22.19	936.96	20795.24
6#	m³	622.5	28.22	485.25	612.63	9.87	936.96	9249.55
8#	m³	397	15.01	301.53	380.68	16.32	936.96	15289.66
10#	m³	120	14.71	103.04	130.09	-10.09	936.96	-9452.05
12#	m³	165	15.31	107.04	135.14	29.86	936.96	27979.50
2#	m³	488	21.92	369.16	466.06	21.94	936.96	20552.69
Subtotal						93.42		87533.97
Fees							6.56%	5742.23
Taxes							9%	8394.86
total								101671.05

The calculation formula of engineering quantity is as follows: e=A-D* f * (1+R)

In this scheme, all the buildings in the whole plot are taken as the unit to comprehensively calculate the quantity of concrete over grouting of the whole plot. The calculated volume of over poured concrete is 93.42m3, and the visa amount is 101671.05 yuan. In addition, It is reasonable to consider all the buildings of the whole plot without deducting the volume of pile head and reduce the owner's cost appropriately.

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Scheme 4:

Building name	Unit of measurement	Actual quantities	Pile head volume	Design volume	Pouring volume	Excess injection volume (buckle pile head)	Comprehensive unit price (yuan)	Excess cost (yuan)
1#	m³	378.5	21.92	312.32	394.30	-37.72	936.96	-35343.16
3#	m³	262	27.32	222.51	280.92	-46.24	936.96	-43325.21
4#	m³	887.5	28.22	672.83	849.45	9.83	936.96	9210.42
5#	m³	274	15.91	199.45	251.81	6.28	936.96	5885.95
6#	m³	622.5	28.22	485.25	612.63	-18.35	936.96	-17193.35
8#	m³	397	15.01	301.53	380.68	1.31	936.96	1224.29
10#	m³	120	14.71	103.04	130.09	-24.80	936.96	-23236.12
12#	m³	165	15.31	107.04	135.14	14.55	936.96	13632.82
2#	m³	488	21.92	369.16	466.06	0.02	936.96	17.24
Subtotal						-95.12		-89127.13
Fees							6.56%	-5846.74
Taxes							9%	-8547.65
total								-103521.52

The calculation formula of engineering quantity is as follows: e=A-D*f*(1+R)-T

In this scheme, all the buildings in the whole plot are taken as the unit to comprehensively calculate the concrete over grouting quantity of the whole plot, and the pile head work quantity t is deducted. The calculated volume of over poured concrete is -95.12m ~ 3, and the amount is -103521.52 yuan. No visa is required.

For the owner, the best scheme is scheme 4, and for the construction company, scheme 1 is the best scheme. However, after many consultations between the construction unit and the owner, the third scheme acceptable to both parties is finally selected as the final visa scheme.

5. Conclusion

Bored pile reinforcement method is widely used in foundation treatment engineering because of its economic, reliable, fast construction speed and low cost. However, it is very rare that there are obvious karst caves and cracks around the bored pile. In addition, the measurement standard of bored pile in the list and quota specification is not clear.This series of reasons lead to some controversial issues in the visa application of this case. I will only summarize the experience in dealing with this case as follows: 1. The filling coefficient and loss rate should be considered in combination with the quota when calculating the excess grouting volume of pile foundation concrete. 2. Make statistics of pouring volume during concrete tank truck pouring. 3. As the pouring volume of single pile cannot be determined during pile foundation pouring, we can measure the concrete volume of the whole building seat as a unit. 4. Whether the pile head volume is deducted in the calculation of excess grouting volume should be determined according to the actual situation of the site pouring. The pile head is mainly the mixture of soil and

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concrete.When the soil proportion of pile head is too large, the volume of pile head shall be appropriately deducted, and the pile head shall not be deducted when the concrete proportion of pile head is large.

Adverse geological factors often lead to the rise of engineering construction cost. Only by doing a good job of geological survey before engineering design and ensuring the accuracy and reliability of survey results, can such things be reduced or avoided.When the construction must be carried out in the place with poor engineering geology, excellent foundation reinforcement scheme should be selected, and measures should be taken to control the cost on site. It is hoped that the treatment method of this project case can help and guide the engineers who encounter this problem in the future. It is expected that the list and quota specification of our country can be further improved.

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