Causes and Solutions for the Common Problems in Rotary Drilling Cast-in-place Pile Construction

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Abstract. Quality control in the rotary drilling cast-in-place pile construction is of great difficulty. Once a quality problem occurs, it would have an impact on the quality of the whole project. The text mainly analyzes the causes for the common problems in rotary drilling cast-in-place pile construction and gives some corresponding measures to solve them combined with engineering cases.

Introduction

Rotary drilling cast-in-place piles to adopt a rotary drilling rig to pierce and form a pile. According to the methods of piercing, it could be divided into rotary drilling cast-in-place pile in dry operation, rotary drilling cast-in-place pile in damp operation, all steel casing and protective wall of rotary drilling cast-in-place pile. In recent years, rotary drilling cast-in-place pile construction has been a new-type construction method for pile foundation, which is employed in bridge and building engineering projects and has a broad application prospect.

Take Chongqing area as an example, manual cast-in-place pile construction has been eliminated due to the lack of operational safety assurance for workers and the low efficiency during the process. Given the rock high fill mountainous geological conditions of Chongqing area, rotary drilling cast-in-place pile is the first choice for pile foundation. But in the application process, many quality problems occur, such as hole pull collapse, bottom sediment, reinforcing cage float, and localized necking in the pile hole. They have caused a profound influence on the quality of the rotary drilling cast-in-place pile. If the problem could not be solved in time, it would have detrimental effects on the quality of the entire project. Therefore it requires engineering staffs’ high attention during the construction.

The common problems in rotary drilling cast-in-place pile construction and cause analysis

1.1 Water emitting of steel casing. The outer wall of the steel casing emits water. The more serious cases will induce foundation subsidence, incline and displacement of the steel casing, which will cause pile hole deviation. Even it is hard to go on the construction. The main reason is that the earth around it is not dense enough when it is embedded, or the water level in the steel casing varies largely, or the bit hits it when it rises and falls.

1.2 Slow drilling or no drilling footage. Drilling is slow in hard plastic clay layers. Generally, it takes 8 to 10 hours, which accounts for 60% to 70% of the penetration time for on pile. It is mainly for the reason that the type of bit is incorrect, setting angle for the alloy cutter is improper, the depth of earth cut by a cutter is too shallow, the bit counterweighs, and the bit is thoroughly coated with clay.

1.3 Collapse of the wall of pile hole. After and during the piercing, the wall collapses in varying degree. Bubbles appear constantly in the emitted mud. Sometimes the water level decreases suddenly. All of them are the harbingers of collapse. The main reasons are that the earth is lax, the mud protective wall is not good enough; the embedding of the steel casing is bad, the inner water level is not high; the speed of the bit is too fast or its idling time is too long are causes for the bottom collapse. Or waiting and perfusion time after piercing is too long.
1.4 Localized necking in the pile hole. Localized necking means that localized hole size is smaller than the designed size. Poor performance and large water loss of mud causes water swelling of plastic layer or form lax honeycomb thick mud cake; improper distance between neighboring pile constructions, the stresses in the layers of soil has not been diffused, soft clay creeps in new holes, or the bit size wears excessively are the main causes.

1.5 Displacement and incline of pile hole. Great vertical deviation or bends appear after piercing. The main causes are that the installation of the drilling rig is not flat or the virtual earth under the platform causes uneven sinking; pile holder is unstable, drill pipe guide inclines, underground barriers like old foundation or big rocks, heterogeneous foundations or bedrock inclines.

1.6 Too much sediment in the bottom. Silting in the bottom; extremely thick residual mud sandy or the collapsed walls drop into the bottom. It mainly due to the fact that the hole is not completely cleaned, the percentage of mud is low or it is replaced by clean water in the cleaning process; the hanging position of steel reinforcement cage is not directed at the center; the earth scrubbed drops into the bottom; concrete pouring is not in time after cleaning the hole which causes the mud sediment and there is no unify bottom elevation which measures the thickness of sediments.

1.7 Steel reinforcement cage floats. Steel reinforcement cage floats, apart from the obvious reason that catheter raises the hook, the main reason is that the surface of concrete is right to the bottom of steel reinforcement cage, the bottom of catheter is 2 to 3m below the bottom of steel reinforcement cage, the speed of concrete pouring is fast so that the dropped concrete strokes upward, its buoyancy is more than the gravity of steel reinforcement cage.

Control measures for common problems occurred in rotary drilling cast-in-place pile construction

2.1 Guarantee embedding quality of steel casing. Choose and tamp clay which has the optimal water content when embedding the bottom and walls of steel casing; dig a hole in the proper height in the steel casing so as to retain 1-1.5m water head height within it; prevent the bit from hitting the steel casing in rise and fall; fill and tamp the steel casing with clay when it emits water for the first time. If it falls or displaces seriously, it should be reworked and embedded again.

2.2 Change bit in time according to the soil condition. Change or improve the bit, rearrange the setting angle, shape, and orientation of the cutter, increase weights, reinforce sediments emission, reduce mud percentage or use drilling method, adopt reverse circulation drilling method.

2.3 Adjust the percentage of mud in time, and careful manipulation to prevent the collapse of hole. Deeply embed steel casing in lax soil layer, tamp the soil, use high grade mud, increase the percentage and viscosity of mud, raise the steel casing, add mud after well completion, keep the required water head height, guarantee the manufacturing quality of steel reinforcement cage, prevent transformation; align with the hole in hoisting, hang direct and guide, sink slowly, prevent hitting the wall; after the piercing, pouring concrete in time, the interval is no more than 3 hours and quicken the speed and reduce the time as much as possible; before placing the steel reinforcement cage in the hole, backfill the cement mortar, clay composite to the place which is 1-2m below the collapsed hole depth, or backfill and tamp the whole hole and then clean the bottom of the hole with the original bit and high grade mud. In the case that a slight collapse caused the steel reinforcement cage, use the bit, of which the size is shorter than that of steel reinforcement cage and high-grade mud or catheter to clean the hole.

2.4 By adjusting the percentage of mud and adopting excavation method to assure that no contractive necking occurs. When you have predicted or the necking has happened, you should use high-grade mud, control the share and viscosity of mud and reduce water loss. When the designed distance between two piles is less than 4D, you should construct in every two or three piles; the construction of a new pile should be started 36 hours after the piling of its neighboring pile; choose a double guide gauge protection cage bit; use mud and full-scale bit to clean the hole and finish concrete-filled steel tube after cleaning the hole as soon as possible.
2.5 Ensure that the drilling rig has been installed to the right position, check and adjust in time during the construction. The installation should be upright, flat, stable, three points: front edge tangent point, swing center and steel casing center should be in the same surface and same line; steel casing does not incline, drill pipe is not bend, drive rod keeps upright; add guide frame, control and hang the swivel; adopt collar to pressurize where is possible; clean underground barrier; except the adaptation of light reduction and slow shift technique parameters in soft and hard layers, from the soft plastic clay layers, especially when enter the hard plastic clay layer from flowing plastic clay layers and sand layer or from soft soil layer to bedrock, the taper guide bit in the bottom should be changed into flat guide bit or bit without a guide; adopt open caisson or pile hole digging to clean underground barriers; when the inclination occurs in the hard plastic clay layers, use the mixture of sand and soil to backfill the area 1-2m higher than the targeted area, when it becomes dense enough, use flat alloy bit to have a light reduction and slow shift on the inclination; when the bedrock inclines, throw rubbles, of which the size is from 20-40mm, to the area which is a little bit higher than the inclination area, when it is dense enough, use flat alloy bit, rolling bit or flat calyx bit to correct it.

2.6 Assure the quality of hole cleaning. Raise the bit by 10-20 cm from the bottom after piercing, keeps slow steering and more than 30 minutes’ cycle time; use high-grade mud in cleaning hole, control the share and viscosity of mud and do no replace mud with clean water directly, steel reinforcement cage should be put on the bottom slowly and horizontally; the thickness of sediment is accounted from the bottom surface of the hole; raise the impact of concrete on the bottom of the hole in the first pouring, the distance between the bottom of catheter and the bottom of the hole should be controlled within 30 to 40cm. The amount of concrete in the first pouring should satisfy the requirement that the end of the catheter could be embedded more than 1.0m in the concrete, use interval blocking and concrete to clean the residual sediment.

2.7 Slow down the concrete pouring speed and reduce the floating of steel reinforcement cage. To prevent the floating of steel reinforcement cage, you need to slow down the concrete pouring speed when the end of the catheter is lower than the bottom of the steel reinforcement cage by 2 to 3m and the surface of the concrete is within 1m higher or lower than the bottom of steel reinforcement cage. The fastest speed permitted by the drilling rig is related to the size of the pile. When the concrete surface has been higher than the bottom of the frame by 4m, raise the catheter to the height, which is 2m higher than the bottom of the frame, and then get back in a normal pouring speed. Except for the above-mentioned method, steel reinforcement cage itself should be accounted for. The common method is to weld and fix the frame on the steel casing, or to reduce the amount of stirrup below the steel reinforcement cage to a proper amount (within 2m below it); or to extend the four main reinforcement in the frame to the bottom of the hole; or to install one or two stiffening reinforcement, of which the size is no less than that of the main reinforcement, and weld proper traction reinforcement on the bottom of the steel reinforcement cage. When the floating of steel reinforcement cage occurs, the pile driver stops pouring concrete immediately, control the steel reinforcement cage with the help of some equipment like steel casing and drilling rig. When the floating is little, slow down the pouring speed when it has been controlled; when the floating height is large, the pile could not satisfy the requirement of design, you need to draw the steel reinforcement cage, clean the hole and re-pour concrete.

Conclusions

Rotary drilling cast-in-place pile is a new type of building foundation pile construction craft, which can be applied to all kinds of complicated geological conditions like flowing mud, soft soil, gravel and quicksand in the rotary drilling pile construction. Because of fast speed of drilling bit, high degree of automation, accurate locating, less labor cost, good environmental performance, high working efficiency and low construction cost in the construction process, its value attracts more and more attention. However, in real rotary drilling construction, there are still many above-mentioned problems. In order to have better control over the pile quality constructed through the rotary drilling
cast-in-place pile method, the following several points should be attached importance to in the construction:

3.1 Get prepared before drilling. Such as, understand the geological condition, placement of the field, and mud preparation.

3.2 Keep record and analysis in time during the drilling process, ready to know the geological condition, check indexes like inclination of the hole, percentage of mud frequently, find out problems and adjust immediately.

3.3 When the depth and size of the hole has reached the requirement of design, clean the hole and hang the steel reinforcement cage in time. When the steel reinforcement cage is in position, recheck the thickness of sediment in the bottom and clean the hole for the second time.

3.4 Take proactive measures to prevent the floating of steel reinforcement cage, and adjust the percentage of concrete to guarantee the quality of concrete.

With rotary drilling cast-in-place pile construction craft becoming more mature, all areas make their local standards. Its construction craft and method get more application. During the construction process, professional technicians’ strict control and master of technology key points are needed, constant experience accumulation, further absorption of advanced technology and craft, guarantee construction quality, and ensure the process of a project and its economic profit.

References


