Construction Technology of Composite Cofferdam for Main Pier Bearing Platform of Dongjiang Lichuan Bridge

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Abstract. Dongjiang Lichuan Bridge in Dongguan City is a curved tower curved beam cable-stayed bridge with a main span of 138m and no back cable. The main pier cap is located on the bank slope of Dongguan Waterway on one side of Nandi Road. The cushion cap is dumbbell type, and the left and right cushion caps are connected by tie beams. In most areas, the top of rock stratum is above the bottom of bearing platform. The rock stratum within the buried depth of bearing platform is moderately to strongly weathered argillaceous siltstone. The geological conditions are complex and the construction is difficult. In line with the principles of speeding up the construction process and improving economic benefits, comprehensive analysis and weighing advantages and disadvantages, the main pier cap adopts a composite cofferdam of filling soil to build an island and combining bored pile rows and steel sheet piles. The construction task of bearing platform of main pier has been completed with high quality. Compared with other cushion cap construction methods, this construction method has the advantages of fast construction, high quality, simple safety, energy saving and environmental protection. This paper briefly introduces the design scheme of composite cofferdam, expounds in detail the operation steps of steel sheet pile construction and the problems needing attention in construction, and provides good reference experience for similar pile cap construction.

1 Introduction

With the development of economy and the need of transportation, a large number of bridge projects are rising. As an important part and process of bridge structure construction, cushion cap construction is widely used in every bridge project. But different geological water temperature environment and construction environment, the corresponding cushion cap construction scheme is different. Therefore, when preparing the construction organization design and construction scheme, the engineering technicians should fully consider the influence of the geological and hydrological conditions on the construction of bearing platform, so as to make the design reasonable, the structure firm and the economy reasonable.

The stratum within the buried depth of the main pier cap of Dongjiang Lichuan bridge in Dongguan City is moderately weathered ~ strongly weathered argillaceous siltstone, and the upper overburden is medium fine sand and muddy silty clay permeable and collapsible stratum. The geological conditions are complex, the depth of the foundation pit is large, and the uneven stress difference of the four sides of the foundation pit is very large. In the excavation, the excavation support and water retaining cofferdam of the foundation pit should be fully considered. The foundation pit near the embankment can usually adopt sheet pile, row pile, underground continuous wall, gravity retaining wall and other types of retaining structure, and double row pile retaining structure can also be adopted. The construction of cofferdam in water often adopts such structural forms as caisson, caisson, double wall steel cofferdam, bored pile cofferdam, locked steel pipe pile cofferda[1-4]. Based on the field investigation and many times of technical discussion, the construction platform of the main pier bearing platform of the bridge is formed by filling the island cofferdam, and the combination of bored pile row piles and steel sheet pile cofferdam is used as the bearing platform foundation pit support to form a composite foundation pit support type.

2 Project overview

The main bridge of Dongguan watercourse of Dongguan Lichuan bridge is a steel-concrete composite girder cable-stayed bridge with curved tower and curved beam and no back cable and harp. The bridge is of pier, tower and beam consolidation structure. Its span combination is 51.5m + 138m + 55m = 244.5m[5]. The bearing platform of the main tower is located at the bank slope of Dongguan waterway on one side of Nandi road. The cushion cap is dumbbell type. The left and right bearing platforms are connected by tie beams. The size of single bearing platform is 15.5m along the bridge direction, 10.0m across the bridge direction, 4.5m thick. The tie beam is 18.5M long, 6m wide and 4.5m thick. The

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covering layer at the pier site is shallow and the rock surface fluctuates greatly. The average elevation of the top surface of the rock stratum is -4.04m, the shallowest part is -0.33m and the deepest part is -6.46m. The top surface of the rock stratum in most areas is above the bottom surface of the bearing platform. The stratum within the buried depth of bearing platform is moderately to strongly weathered argillaceous siltstone, and the upper overburden is medium fine sand, muddy silty clay and other permeable and collapsible strata, with complex geological conditions and uneven bank slope. See Figure 1 for the elevation layout of the main bridge.

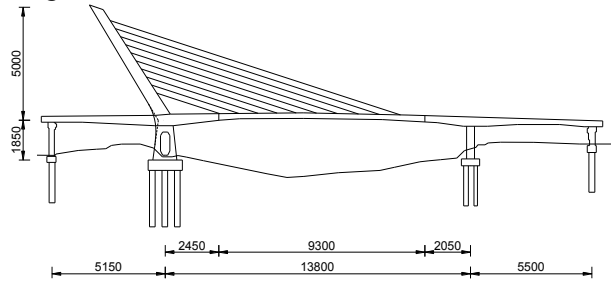

Figure 1. Elevation layout of Dongjiang Lichuan Bridge (unit: cm)

3 Foundation pit support structure scheme

The composite support structure consists of outer edge steel sheet piles, island construction, support bored piles (φ1000 @ 1100), inner edge steel sheet piles, crown beams, and internal supports. The rock surface is uneven in the range of the cap (-0.33 ~ -6.36m), and the length of the supporting bored pile is divided into three areas (11 ~ 17m). The steel sheet pile is of Larson type IV with a single root length of 10m. The design elevation of the steel sheet pile is 4.5m and the bottom elevation is -7.5m. The length of the steel pipe support in the cofferdam is large, and the design size of the steel pipe support is φ800 × 10. The normal water level of the cofferdam is 0.866m, the design and construction water level is 3.0m, and the design construction load is 20kPa. The elevation and plane schematic diagrams of the foundation pit supporting structure are shown in Figure 2 and Figure 3.

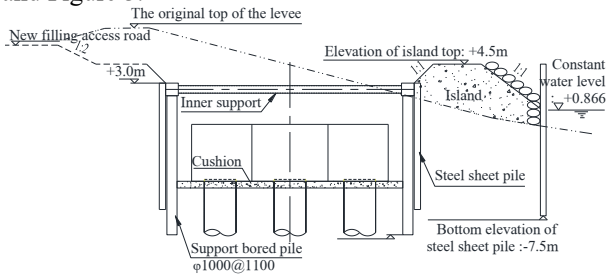

Figure 2. The elevation schematic diagrams of the foundation pit supporting structure

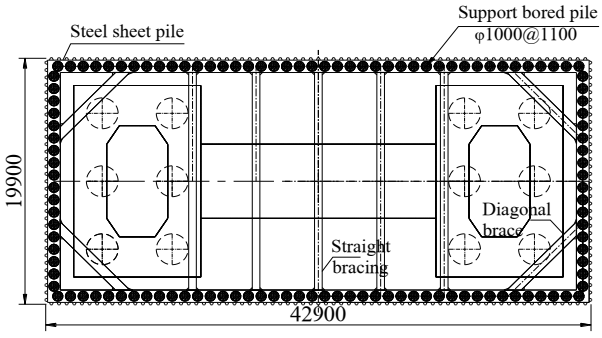

Figure 3. The plane schematic diagrams of the foundation pit supporting structure

4 Key construction technologies

4.1 Island construction

The bridge site at the Dongguan waterway generally has a high tide level of 1.8m and a general low tide level of 0.2m. The top elevation of the island cofferdam is + 4.0m. The outside line of island is 12m away from the side line of the platform facing the water. In order to prevent soil erosion, a row of steel sheet piles is inserted along the outer line before filling. The upper end of the steel sheet piles is connected with 2I56a steel. According to the water depth, a φ600 × 8mm steel pipe pile is inserted around the outside of the steel sheet piles at about 6m to enhance the stability of steel sheet piles. In order to facilitate subsequent insertion of steel sheet piles and cofferdams, the stumps and stones on the bank slope should be removed before building the island. The soil quality of the filling should be cohesive soil with uniform particles.

4.2 Supporting pile construction

After the completion of the construction of the bored piles of the main pier, the leveling site is cleaned up and the supporting piles are constructed. Foundation pit supporting row piles are φ0.8m bored piles with a spacing of @ 1.0m. They are arranged around the foundation pit around the platform. The pile top elevation is + 1.0m, the pile bottom elevation is -9.0m, and the pile length is 10m. The sideline distance of the cap is 1.65m, and the top of the pile is set with a crown beam of 1.0 × 1.0m (height × width). The supporting pile is punched with a smashing machine, a 55t crawler crane is installed with a steel cage, and the pipe is poured with underwater concrete. Supporting piles that have been opened at the same time or successively must be separated by more than 3 pile spacings to prevent the newly poured concrete from being disturbed by the punching construction of adjacent pile foundations. The construction flow chart of bored support pile is shown in Figure 4.

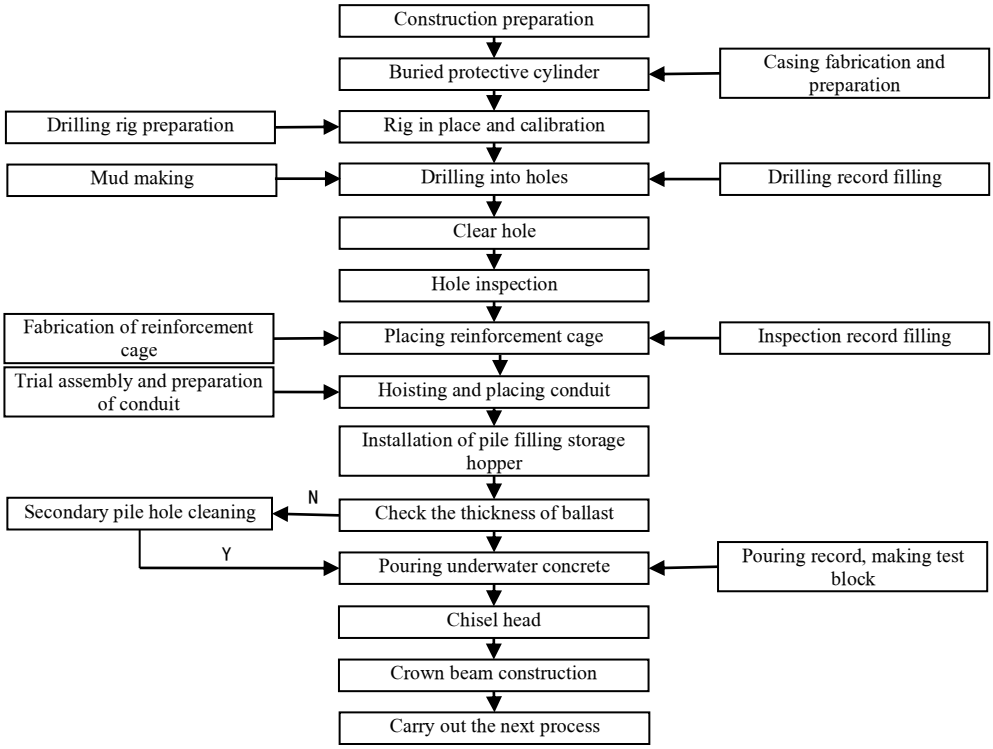

Figure 4. Construction flow chart of bored support pile

4.3 Crown beam construction

After the construction of the supporting piles, the first-level grading excavation of the island construction platform begins. Excavate the top elevation of the Island from + 4.0m to + 2.0m. The sloping slope around is 1: 1. The foot of the slope is about 5m from the outer line of the crown beam, and then the foundation pit of the crown beam is excavated, the pile head is broken, and the crown beam is constructed. After the construction of the crown beam, the crown beam foundation pit is backfilled so as to perform the peripheral steel sheet pile punching operation.

4.4 Inner edge steel sheet pile punching

After the construction of the crown beam, peripheral steel sheet piles were inserted. The steel sheet piles were Larsen IV type, the pile length was 9m, and the hydraulic crawler-type vibratory pile driver was used. The water stopping effect after the steel sheet pile is inserted is the key to the success of the construction of the cap of this method. The steel sheet pile must be inserted into the depth and the lock tightness. The penetration depth of the steel sheet pile must pass through the overburden to enter the strongly weathered rock layer above 50cm. The penetration force is closely combined with the geological survey data, and the dual control of excitation force and depth is adopted. The steel sheet pile is inserted close to the outside of the crown beam when it is inserted. In the case of underground obstacles such as expanded pile diameter and solitary rock, the plane linearity of the steel sheet pile can be adjusted to avoid the obstacle, or the obstacle can be removed by partial excavation before insertion. Be sure to make the steel sheet pile into the strongly weathered rock formation to achieve a good water stop effect. Process flow chart of steel sheet pile driving is shown in Figure 5.

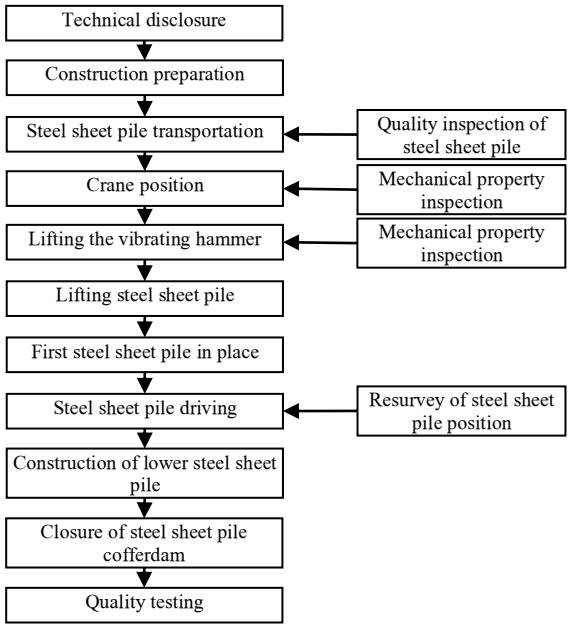

Figure 5. Process flow chart of steel sheet pile driving

4.5 Excavation of foundation pits

After the sheet piles are inserted, excavation of the foundation pit in the cofferdam is started. The foundation pit is excavated with a long-arm excavator and manual excavation. The excavation of the

foundation pit in the cofferdam is divided into two times, the first excavation is to + 0.5m, and then the internal support of the crown beam is installed at an elevation of + 1.5m. The second excavation excavated to the bottom of the cushion at an elevation of -5.3m. In order to ensure that the cofferdam supporting structure was balanced, the excavation in the foundation pit was carried out in layers. The thickness of each layer was controlled at about 2m, and when the depth of the design pit is about 1m, the layer thickness is reduced. During the construction process, it should be measured frequently, and the excavator should be operated carefully to avoid overfilling and backfilling to keep the original structure of the soil at the bottom of the pit from being disturbed and damaged. After the foundation pit is excavated in place, a 50cm thick concrete cushion is poured for the construction of the platform. When there is a small amount of seepage water on the inner wall of the foundation pit, drainage grooves are set around the bottom of the pit, and ponds are set up at the four corners of the foundation pit.

Deformation and settlement observations of the cofferdam supporting structure and surrounding soil are conducted regularly during the entire excavation of the foundation pit until the backfilling of the foundation pit, in order to find abnormal conditions in time and deal with them to ensure the safety of deep foundation pit construction.

4.6 Cap construction and foundation pit backfill

Because the platform is a large volume of concrete, the hydration heat, mold temperature, and concrete thickness of the concrete should be controlled during construction, and cooling water pipes should be used to reduce the temperature difference between the inside and outside of the concrete to prevent temperature cracks. The test of the surface temperature difference, cooling rate, ambient temperature and temperature strain in the cast body should be no less than 4 times a day and night after the concrete is poured. And the temperature of the mold is measured at least 2 times per shift[6]. See Figure 6 for the horizontal and lateral layout of the cooling platform.

After the construction of the cap is completed and the required curing time is reached, the foundation pit is backfilled in time, the steel sheet piles around the row of piles are pulled out, and the lower tower column is constructed. After the construction of the lower tower pillar is completed, the island-filling is removed, the steel sheet piles on the water-facing side of the island are removed, and the river channel is restored.

5 Conclusion

From March 2014 to September 2014, the concrete pouring of the main pier cap of the Dongjiang Lichuan Bridge was completed, and the construction task of the main pier cap was completed with high quality. Compared with other construction methods, this method has the following advantages and benefits:

(1) Construction organization

The island construction on the bank slope is used as the construction platform, and the on-shore construction is changed to the on-shore construction, which greatly improves the construction efficiency and also lays a good foundation for the subsequent excavation of foundation pits.

(2) Construction quality

The composite support method of concrete row piles and steel sheet piles has a clear structure load and reliable water stopping effect. There is basically no standing water in the foundation pit during the construction of the platform, and the construction environment in the foundation pit is clean and orderly.

(3) Safe and easy construction

After building the island cofferdam, row piles and steel sheet piles are used for support. Two-stage steps are used to reduce the water and soil pressure on the supporting structure, and the advantages of large stiffness, strong adaptability, and good water stopping effect of the piles are fully utilized, which provides a safe and reliable working environment for the construction of the cap inside the foundation pit. The entire construction process is a mechanized operation, which is a common equipment and conventional operation method, and has high construction efficiency.

(4) Energy saving, environmental protection and socio-economic benefits

Reasonably plan the area of the island cofferdam to reduce the width of the invaded river channel, which will not affect the normal navigation of the channel, and save a total of about 1.2 million RMB.

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