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**Research Article**

**Study on the Installation and Construction Technology of the Transfer Stairway on the Track Platform on Bridge—— Taking the Construction of the Jialing River Bridge in Zengjiayan of Chongqing City as an Example**

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**Abstract:** The bridge deck on the Yuzhong side of Zengjiayan Jialing River Bridge is close to subway lines and light rail stations. It is necessary to set up transfer stairways on both sides of the bridge. The construction technology of installing and replacing with tunnel under special conditions is discussed to provide reference for bridge construction.

**Keywords:** Track platform on bridge; Transfer stairway; Bridge construction

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**1 Introduction**

The Zengjiayan Jialing River Bridge in Chongqing is a cross-river passage of the Zengjiayan Bridge Project and Track Line 10, located between the Huanghuayuan Bridge and the Jialing River Bridge. The upper part of the lower deck on the Yuzhong side of the Zengjiayan Jialing River Bridge is Metro Line 10 and its station, and the lower deck is the light rail station of Line 2 that crosses spatially. In order to secure the pedestrian transfer from the subway station to the light rail station, transfer stairways are constructed on both sides of the bridge. The platform section of the transfer stairway adopts a box-shaped section, with a beam height of 0.9m and a width of 3.5m. The transfer stairway on each side of the bridge consists of three segments, which are supported on the concrete corbel on the pier and the steel corbel on the main truss respectively. The steel corbels were installed on the lower chord respectively.

**2 Construction Requirements**

The bridge installation of this project has the following characteristics: the coordination of the bridge and the river is required, and the construction of the 3D crossing. The construction environment is poor and the hoisting space is limited. High-altitude operations require high level of coordination between operators and cranes. The structural size of the components is large, the hoist load is heavy, the components are eccentric, and the hoisting requirements are high. The hoisting space is limited, and the main boom of the crane needs to pass through the stiffened suspension. The transfer stairway is located directly below the upper sidewalk and could not be directly hoisted in place, and must be dragged and installed horizontally. Two cranes were used to carry out the hoisting installation, and the requirements for hoisting command and hoisting technology are high. Across the Jialing River, navigation under the bridge requires high level of safety and environmental protection. It is located in a high-density residential area and the surrounding environment is complex, such as the highway along the river under the bridge.

Project construction requirements: All steel stairways must meet the design requirements before leaving the factory, and unqualified steel components are strictly prohibited from being transported to the construction site. The equipment used for the installation of the stairway platform shall have a certificate of conformity, and the operation shall strictly comply with the requirements of safe production. The protection of the platform edge must be carried out simultaneously during its operation, and it must meet the requirements of current construction regulations and mandatory safety standards. The project leadership system must be strictly implemented during the whole construction process of the stairway platform. Carry out full inspection of the equipment before hoisting operations, and strictly implement the inspection and log system. When hoisting heavy objects with two cranes, the weight allocated to a single crane shall not exceed 80% of the allowable hoisting capacity of the crane, and the total weight of the components shall not exceed 75% of the sum of the rated hoisting capacity of the two cranes, and unified command is required. The method of hoisting equipment or components to target position by two cranes: When hoisting, conduct a trial hoisting first, so that the operators coordinate with each other in actions and keep the operating speed of the cranes as unified as possible. The hoists are directed by experts, and at the same time, ensure the smooth communication of the hoisting and the upper and lower level of operations. All special operation personnel must be licensed to work. Strictly implement the three-level technical disclosure and annotation, and all operators must be trained and qualified before they can work.

**3 Construction Technology**

**3.1 Construction Preparation**

130t truck crane machineries and other small machineries were organized to enter the site. Enter the site with corbels installation operating platform components, construction labor protection supplies, life-saving supplies and other materials. Before construction, the Corbel 3 and Corbel 4 should be installed on the support, and the elevation should be re-measured. Water and electricity supply on site should meet the construction requirements. Before the components were brought to the site, trials of components hoisting were conducted in the processing plant. The same spreader slings to be used on site were used in the trials. Check that the components were hoisted smoothly and are safe and reliable before conducting construction on site. Various quality certificates of the products were collected and checked in time. The transfer stairway needs to be constructed in segments, as shown in Figure 1.



**Figure 1.** Segmental Diagram of the Transfer Stairway

**3.2 Operation Platform**

The under-bridge inspection trolley was used as the operating platform for personnel to go up and down and assist with the installation. Meanwhile, a section steel pylon was put up on the steel corbel after installation, which served as a platform for later-stage stairway parallel-shifting personnel to suspend guiding chains and assist with operations. Personnel operated from the top of the pier onto the corbel. Meanwhile, a protective railing was installed around the concrete corbel. When installing Stairway 3, the personnel on one side stood on the installed Stairway 2 to assist with installation. After Stairway 3 had been roughly positioned, the hoisting point was not removed, and the personnel walked through Stairway 3 to the position on Corbel 2, and then suspended a steel bar hanging frame on the concrete Corbel 2 as a personnel manipulation platform for precise positioning. Stairway 1 was put up on the lower bridge deck with suspension points, and the guiding chain was used to drag the platform into position. The steel bars embedded in the concrete corbel were used as the anti-pull points on Stairway 2, and the guiding chain was suspended for horizontal dragging.

**3.3 Corbel Installation**

The manufacturing of corbels and stairway unit components (segments) was completed in the factory. The segment of Stairway 2 was assembled from the original two segments into one in the factory. The bridge was hoisted in whole segments, and steel transfer stairway platforms were put up on both the upstream and downstream sides of the steel truss beam. The construction of the steel stairway on the upstream side was carried out first, and the construction of the steel stairway on the downstream side was carried out after the upstream side construction had been completed. The corresponding components were transported on transport ship to directly below the bridge installation site *via* the Jialing River, and the transport ship was anchored after reaching the assigned position. The corbel was hoisted and installed by a single 130t crane. The 130t machinery carried out hoisting on the upper bridge deck and the wire rope was passed through the top of the stiffened suspension cable. The hoisting distance was 10 meters, the rated hoisting weight was 30t, and the corbel weight was 1.6t, fulfilling hoisting requirements. After the corbel was installed, a rubber pad was installed on the corbel and its top surface was measured. The top surface of the corbel is required to be flush and the elevation met the design requirements[1]. Figure 2 illustrates the hoisting installation of the corbel.





**Figure 2.** Schematic Diagrams of the Hoisting Installation of the Corbels.

**3.4 Stairway 2 Hoisting Installation**

The Stairway 2 was hoisted and installed by two 130t cranes, the center of Crane 1 was aligned with S31, the center of Crane 2 was 7.5m from the upper S32 node, and the center of the hoisting point was 8.6m from the center line of the bridge deck. The installation of Stairway 2: the hoisting distance of Crane 1 was 11.5 meters, the rated hoisting weight was 31t, and the hoisting weight was 22t (pulling separation taken into consideration), which meets the hoisting requirements. Stairway 2 has the heaviest weight and the largest structural size, making it difficult to install. In order to prevent the installation of Stairway 2 from colliding with other stairways, Stairway 2 was installed first. The rod components were transported directly below the installation site on barge. When hoisting, Crane 1 started hoisting first and shifted into the installing conformation, then the two cranes carried out hoisting in tandem. During the hoisting process, Crane 2 gradually raised the arm to adjust the posture. When hoisting, a sliding rope must be used for the components to avoid rotation of the components during hoisting. After hoisting to a slightly higher height than the installation height, on the steel corbel side of Stairway 2, lifting lug was welded on the bridge deck as anchor point for dragging components. On the concrete corbel side of Stairway 2, using embedded bars as anchor points for dragging, the components were dragged horizontally to right above the corbel with the 10t guiding chain, lowered to the corresponding position, and then lowered and fixed in place. On the steel corbel side of Stairway 2, the construction workers allocated on the lower chord rod components of the side stringer dragged and positioned Stairway 1, and then unhooked the lugs after the installations were in place. On the concrete corbel side of Stairway 2, the construction workers climbed down the stairway through the steel beam to the concrete corbel to carry out construction work.

**3.5 Stairway 1 Hoisting Installation**

Stairway 1 was installed by two 130t cranes. The center of Crane 1 was aligned with S30, the center of crane 2 was aligned with upper S31, and the center of hoisting point was 8.6m from the center line of the bridge deck. The main booms of the crane all passed through the top of the rigid suspension cable. The maximum hoisting distance of crane 1 was 12.1 meters, the rated hoisting weight was 37t, and the hoisting weight was 4.9t (pulling separation taken into consideration), which meets the hoisting requirements. Crane 2 has a maximum hoisting distance of 11.5 meters, a rated hoisting weight of 29t, and a hoisting weight of 4.8t (pulling separation taken into consideration), which meets the requirements of hoisting. The rod components were transported directly below the installation site on barge.

Crane 1 started hoisting first and shifted into the installing conformation, then the two cranes worked in tandem. When hoisting, a sliding rope must be used for the components to avoid rotation of the components during hoisting. After the hoisting was slightly higher than the installation height, lifting lugs were welded on the bridge deck as anchor points for the component dragging. The components were dragged horizontally with a 10t guiding chain to right above the corbel and lowered to the corresponding positions, and then lowered and fixed in place. The construction workers allocated on the lower chord rod components of the side stringer dragged and positioned Stairway 1, and removed the lugs after the installation was in place[2]. Figure 3 illustrates the hoisting installation of a stairway.

**3.6 Stairway 3 Hoisting Installation**

Stairway 3 was installed by a 130t crane, the center of the crane was 9.56m from the S32 node, and the center of the hoisting point was 8.6m from the center line of the bridge deck. The main boom of the crane was 32m long, passing through the lower part of the rigid suspension cable. The net distance of the rigid suspension cable boom of the lifting section was 0.7m, and the hoisting installation main boom m was 3m away from the rigid suspension cable. Installation of Stairway 3: the maximum hoisting distance of the crane was 14.4 meters, the rated hoisting weight was 27t, and the hoisting weight was 8t (pulling separation taken into consideration), which meets the hoisting requirements.

The rod components were transported directly below the installation site on barge. Long and short wire ropes were installed, where the long wire ropes were about 7m long and the short wire ropes were about 5.5m long. Trial hoisting was carried out to adjust the installing conformation. After the overall hoisting was slightly higher than the installation height, the main boom was raised directly above the installation position on Stairway 3. After the components were lowered to the corresponding positions, they were fixed in place. A sliding rope must be used for the components to avoid rotation of the components during hoisting. Construction workers used steel beams to climb down the stairway to the concrete corbel for dragging and positioning, and after installation is in place, unhooking was carried out[3]. Figure 3 illustrates the hoisting installation of the Stairway 3.



**Figure 3.** Hoisting Installation of Stairway 3.

**3.7 Auxiliary Railing Hoisting Installation**

After the stairway is installed, install the stairway railing and other auxiliary facilities.

**4 Conclusion**

Select installation techniques and mechanical equipment for stairway installation according to local site conditions to prevent dangerous operations and ensure installation quality.

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