Key Technology of Prefabrication Construction of Portal Pier Bent Caps with Large Cantilever

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Abstract. In order to ensure the smooth flow of municipal roads and avoid a large number of demolition and renovation operations, the substructure of the Rama III to Outer Bangkok West Ring Expressway project is designed as a cap beam of portal pier, and the construction adopts the fully-suspended short-line combination method, in which two spans are equipped with large cantilever structures. For portal pier with large cantilever structure, the construction technology of "prefabricated U shell+fully suspended segment assembly + internal cast-in place" is adopted by comparative study. The application results show that this method can realize the construction of portal pier with large cantilever cap beam under complex municipal conditions, and has the advantages of short construction period, small traffic interference and high safety.

Keywords: Bridge engineering; Bent caps; Large cantilever; Segmental assembly; U-shell concrete; Construction technique

1 Introduction

The design and construction of viaducts in municipal road and bridge projects are often greatly affected by traffic and surrounding buildings, and the installation of prefabricated Bridges with machinery as the main method and manual as the auxiliary method can solve this problem well. Its excellent characteristics include high standardization of production, fast and convenient installation on site, reduced impact on the surrounding environment and road traffic, and easy guarantee of engineering quality. Meet the owner's requirements. Combined with Thailand Rama III project, this paper deeply studies the technical difficulties of prefabrication construction of pier column cover beam of municipal bridge, and deeply discusses the key points of construction technology.

2 Project Overview

Thailand Rama III project is located in the center of Bangkok, the capital of Thailand, and the municipal viaduct project that across the existing expressway and highway

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ramp, the road is flanked by residential areas. At the end of the mark is a small curve turning section, with the minimum turning radius R=150m. Because the upper span has viaduct and is close to residential areas, the cover beam of MLP11-23 at the end of the mark is designed as a double-pier column with cantilever beam structure, and the maximum length of the cantilever beam is 13.7m, as shown in Figure 1and 2.

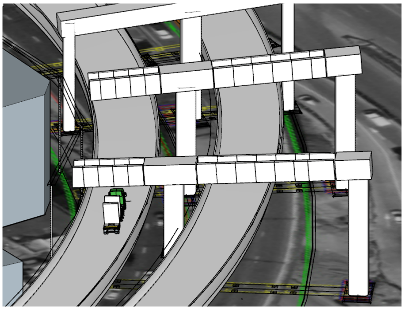

Fig. 1. Design of Portal Pier Bent Caps

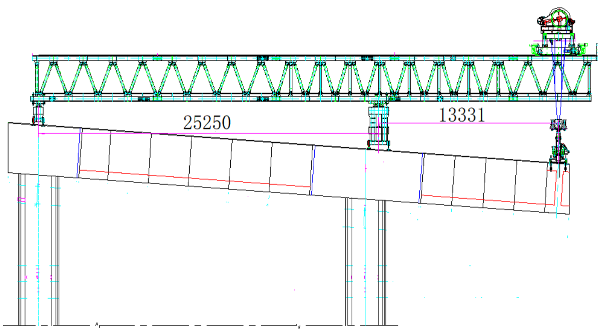

Fig. 2. Segmental assembly of U shell

During the construction of the project, the existing viaduct should be unblocked in the day, and the upper span portal pier bent caps can only be constructed from 22:00 at night to 5:00 the next day; According to the installation schedule of the upper section box girder, the construction time of the 2-span bent caps there is only 1.5-2 months; At the same time, there are a large number of communication lines and 69KV high-voltage lines under the cantilever beam, as well as color steel sheds in existing residential areas. On the premise of meeting the design requirements, saving the cost as much as possible and not affecting the construction period of the key line for box girder, selecting the appropriate construction technology is the key problem faced by the project.

3 Overall Construction Process Comparison

According to the construction boundary conditions of the project, there are several construction schemes that can be selected[1~3]:

1) In-situ casting construction. Under the cantilever beam, there are a large number of communication lines and 69KV high voltage lines as well as existing residential color steel shed. If temporary support is added, the existing color steel shed needs to be removed, the existing communication lines need to be moved to the underground, and the existing high voltage lines need to be partially replaced with safety cables. The cost is huge, Therefore, the site does not have the conditions to add temporary support on the cantilever side and use cast-in-place technology.

2)Solid prefabricated segment assembly process. The assembled segment structure does not meet the shear design requirements and greatly exceeds the rated weight of the existing suspension equipment's overhead crane and full suspension load. Therefore, it is necessary to make significant modifications or replace the suspension equipment with new ones.

3)Suspension pouring process. The existing suspension equipment is used, and the suspension cast-in-place process can meet the design load requirements. However, the concrete load of the cast-in-place process exceeds the rated value of the existing suspension, which requires renovation of the existing suspension equipment. The renovation cost is high and the period is long.

4) Balanced Cantilever Erection Technology. The construction period is longer, the safety risk is greater during construction, and the hanging basket equipment needs to be re-purchased, and the cost is larger.

Based on the requirements of comprehensive design, owners, and consultants, a fifth solution was indicatively proposed through brainstorming and comparative research: prefabricated U-shells+fully suspended segment assembly+internal cast-in-place. After review by the design unit, it meets the load requirements during construction and operation periods. At the same time, after verification by the suspension equipment manufacturer, the existing suspension truss is reassembled to meet the requirements of lightweight U-shell assembly.

4 Main Construction Technology

4.1 Construction of Pier Top 0 # Block

The top block of the cap beam pier adopts cast-in-place construction with few supports, and a through core steel rod and hanging seat are installed in the reserved hole, as shown in Figure 3. The size of the through core steel rod is: the outer diameter of the upper and lower rows is 110mm, the inner diameter is 52mm, and the length is 1100mm, and it is anchored with precision rolled threaded steel with a diameter of 48mm. Then install a wedge jack on the hanging base for adjusting the height, and anchor the wedge jack to the hanging base. Install the support main beam on the wedge jack and anchor the main beam to four wedge jacks using U-bolts. The bracket is supported on the pier body to reduce the amount of bracket work. The 0 # block bracket at the pier top is shown in Figure 4.

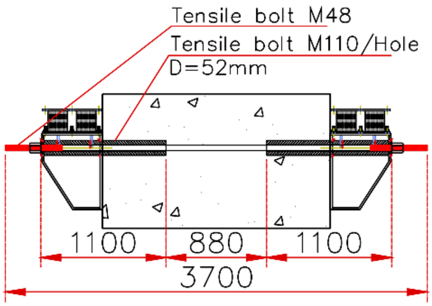

Fig. 3. Installation of core steel rod and hanging base

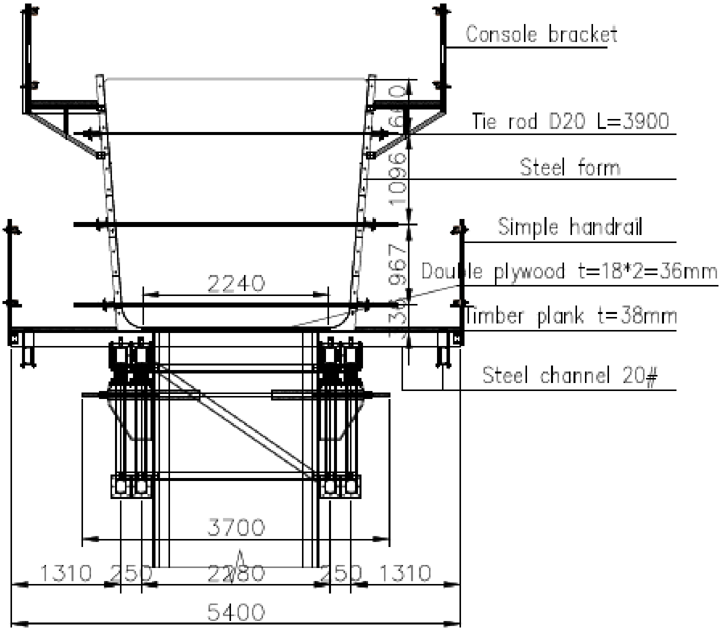

Fig. 4. Cast-in-place of top block for bent caps

4.2 Segmental Prefabricated U-Shells

The prefabricated U-shell segments are factory prefabricated using the short line matching method. Temporary tensioning grooves are reserved on the outer side of the prefabricated segments, temporary tensioning gear blocks are reserved inside, and DB32 precision rolled threaded steel is reserved on the top surface to ensure that there is no relative sliding between the hanger and the segment blocks when adjusting the 7% cross slope. The short line matching method is used for prefabrication as shown in Figure 5.

Fig. 5. Prefabricated U-shell segments

Fig. 6. Segment block alignment

4.3 Hoisting Main Truss Installation

The main truss is hoisted in pieces, and the main girder is placed in the blocked area in advance. After the road closure is completed at night, the main beam is transferred to the cover beam, and 130t crawler crane is used for hoisting.

4.4 Section Block Hoisting and Beam Adjustment

Three days before the hoisting of segment blocks, it is necessary to communicate with the prefabrication yard in advance to confirm the transport vehicle and the hoisting sequence, and organize the quality inspection department to carry out the quality acceptance of prefabricated blocks. According to the direction of the prefabricated block, the assembly of the spender and the turning position of the vehicle are determined to ensure the suspension working space and flow construction.

A 25t truck crane is used to install the hanger, the hanger holes are inserted into the segmental block reserved for the lifting holes, and the 32-finished rolled steel rebar is used to tighten the anchors. After the segmental block is in place, the 50t crane is used to lift the segmental block, and the anti-fall net is installed at the same time. After the segmental block is initially in place, the fine-rolled steel bar is used to lock the hanger with the main truss, release the main crane, and lift the subsequent segmental blocks one by one. Due to the limited driving height, the hoisting cannot adopt the high and low hanging mode. The prefabricated block near the pier column is temporarily placed on the ground. After the fine adjustment of the segment block is completed, the prefabricated block is suspended twice, as shown in Figure 6.

4.5 Temporary Stretching

After the suspension is completed, a crane is used to coordinate with the measurement team for rough position adjustment. Four through center jacks are used to perform precise position adjustment on the main truss, and the adjustment is carried out step by step from the middle to both sides[4]. After the first section adjustment is completed, limited small steel is installed at the wet joint position. The top surface is connected to the reserved hole of the lifting tool with precision rolled threaded steel, and the side is fastened with T-shaped iron and precision rolled threaded steel to the cast-in-place section and the first prefabricated section, The temporary prestressing of other prefabricated segments is applied through the reserved holes on the top surface of the lifting device and the concrete tooth blocks inside the segment blocks. The temporary tensioning requires a matching surface of 0.2Mpa. After design verification, 23 tons of tension are required for the first threaded steel, and 45 tons for the second threaded steel[5]. The temporary tensioning setting is shown in Figure 7.

Fig. 7. Tensioning temporary prestressing on the outside of the U-shell

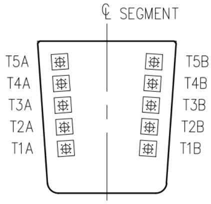

Fig. 8. Profile 1 tendon

4.6 Wet Joint Concrete Placement and Prestress Construction

After the segmental block positioning is completed and the temporary tensioning and anchoring is completed, the permanent prestressed steel strand threading and tensioning are carried out simultaneously on both sides using the hanging basket suspended on the main truss as the operating platform and the high-power bundling machine. Before bundling, use an air compressor to clean the holes. During bundling, open the holes through the wet joint and adjust the position of the steel strand. After bundling, connect the cast in situ section to the reserved corrugated pipe of the prefabricated section at the wet joint using a corrugated pipe[6]. When the strength of the wet joint concrete reaches 25Mpa, prestressing ten holes in the U-shell is carried out in the first stage, as shown in Figure 8.

A total of 25 steel strands are arranged for prestressing the cover beam, which are tensioned in three stages: 10 strands in the first stage, 9 strands in the second stage, and 6 strands in the third stage, as shown in the following figure and Table 1.

Table 1. Tendon details and sequence

Tendon	No.of strands	Tendon profile	Jacking force(kN)	Tensioning mode
T1A~T5A,T1B~T5B	22	1	4297	Both ends
T1C~T3C,T2D~T2D,T3E~T3E	22	2	4297	Both ends
T4C~T5C,T4D~T5D,T4E~T5E	22	3	4297	Both ends

4.7 Suspension Removal and Concrete Pouring Inside the U-Shell

After the prestressed tensioning in the U shell is completed, the hanging and temporary tensioning measures are removed, the internal steel cage is bundled, 15-hole bellow pipe in the cast-in-place section is installed and tightly connected to the cast-in-place section at the top of the pier. According to the design calculation results, the shear force in the wet joint is large, so the concrete in the U shell is poured twice, with the total amount of pouring 1/2 each time. Install the section box girder embeddings and pour the upper concrete.

4.8 Tensioning the Remaining Prestress

When the strength of the core-filled concrete meets the design requirements, the second stage of prestressed tension is carried out, with a total of 9 strands (T1C~T3C, T1C~T3C, T3E~T3E), as shown in Figure 9 below.

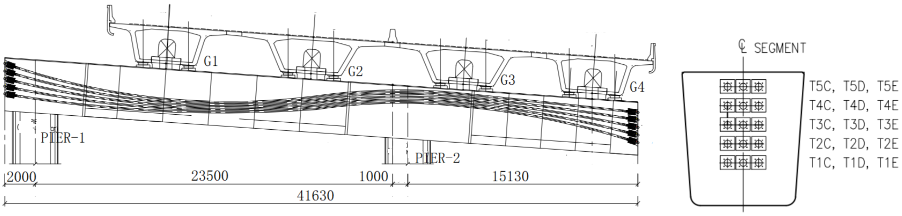

Fig. 9. Profile 2 and 3 tendon

After the erection of the main beams of the superstructure G1, G2 and G3, the third stage of prestress is tensioned, a total of 6 bundles (T4C~T4E, T5C~T5E), and the main beam G4 can be installed only after the prestressed tension is completed.

5 Conclusion

The prefabricated lightweight U-shell+Internal cast-in-place+staged tensioning process is suitable for the bent caps with long suspension structure, large superstructure load, short construction period and high driving safety requirements. The successful implementation of this process in the Rama Project in Thailand has greatly promoted the construction progress of key lines and ensured the completion of node targets, which has great promotion value. It can be applied to precast bridge superstructure and other precast concrete components to further promote precast assembly construction technology.

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