Key Construction and Control Technology of Long Span Self-anchored Suspension Bridge with Cable Before Beam

Chengming Peng, Zhihui Peng, Jiaqi Li, and Junzheng Zhang

Abstract Shatian Bridge is a self-anchored suspension bridge with a main span of 320 m. It is constructed by the overall construction technology of “cable before the beam”. The main cable is temporarily fixed through the temporary anchorage system, and the main beam construction is based on the main cable. After the main beam is hoisted and welded, the main cable is temporarily fixed, and the tensile force of the main cable is transferred to the main beam to complete the system conversion. The bridge adopts permanent-temporary combined with temporary anchorage, effectively saving the cost. The lifting of the stiffening beam adopts inverted lifting technology. For the area of the short sling in the middle of the span, a non-full-length joist is designed to solve the problem of main beam lifting in the area of the short sling. During the construction, the steel beam of the anchorage section and the auxiliary pier are temporarily consolidated. The temporary cable actively balances the tension of the main cable with clear stress, which is convenient for construction control. Temperature welds are set at both ends of the closure beam section, which not only makes room for the hoisting of the closure beam section but also avoids the structural safety problems caused by the temperature deformation of the steel beam. The slip control method of cable strands based on water bag weight ensures that the main cable does not slip during steel beam hoisting. The length of the sling is increased through the extension rod, and the horn-shaped guide device is added to avoid sling damage caused by the sling colliding with the conduit mouth. Generally speaking, the construction scheme of “cable before beam” adopted by the bridge is reasonable and feasible, which enriches the construction technology of self-anchored suspension bridges and can provide a reference for similar bridge construction in the future.

C. Peng · Z. Peng · J. Li (✉) · J. Zhang
CCCC Second Harbor Engineering Company Ltd., Building A, China Communications City, Wuhan, Hubei, China
e-mail: 196356311@qq.com

Key Laboratory of Large-Span Bridge Construction Technology, Wuhan, Hubei, China

Research and Development Center of Transport Industry of Intelligent Manufacturing Technologies of Transport Infrastructure, Wuhan, Hubei, China

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1 Introduction

Self-anchored suspension bridges have strong competitiveness in bridge engineering in the range of 100 ~ 400 m span because they do not need large anchorage, occupy a small area, and have beautiful structure and shape [1–3]. Since the main cable of the self-anchored suspension bridge is directly anchored on the main beam, the construction sequence of "beam before cable" is usually adopted [4–6], which is precisely opposite to the construction sequence of "cable before beam" adopted by ground anchored suspension bridge. It is challenging to apply the traditional "beam before cable" technology when crossing the busy waterway, with high navigation requirements, high environmental protection requirements, considerable water depth, thin overburden, and rugged construction of steel pipe piles into rock. The technology of "cable before beam" will solve this problem perfectly. There are few pieces of research on this technology, and its practical engineering application is rare.

Wen Shudong et al. [7] put forward the idea of constructing self-anchored suspension bridges with "cable before beam" technology in 2005. Their erection scheme was temporary consolidation of pier beams, transferring the horizontal force in the construction process to the pier, and discussing the design of the pier section. The system conversion was realized by relaxing the temporary consolidation tie rod. Tian Hanzhou [8] and Jia Guang [9] completed the construction of the Beijing Road Bridge (main span 132.5 m) in Huai 'an for the first time by setting temporary anchorage and using a temporary cable to control the displacement of the beam's end.

Generally speaking, the research on constructing self-anchored suspension bridges with "cable first and beam second" is still limited. There is only one small span mixed beam self-anchored suspension bridge in practical engineering application, and the side span has been erected on the support in advance. Only the middle span beam section is lifted and erected, and the side span balances the weight of the middle span erection beam section by tensioning the sling. Generally speaking, it is not difficult to control. Currently, the construction technology of "cable before beam" has not been adopted on self-anchored suspension bridges with a span of more than 200 m at home and abroad.

The main span of south branch of Dongjiang River Harbor Bridge (now renamed Shatian Bridge) in Dongguan is 320 m, spanning the busy waterway, and the designed navigable clearance is 294 × 34 m. The original design is the construction technology of cable first and beams later. In order to reduce the influence of the construction process on the waterway and ensure the safety of the construction process, the construction technology of "cable first and beam later" is adopted after modification. In this paper, the critical construction and control technologies in the construction process of the bridge are summarized to provide a reference for the subsequent construction of similar projects.

2 Engineering Situation

Shatian Bridge is located in Shatian Town, Dongguan City. It is an important channel to cross the tributaries of East and South China and connect all the villages of Shatian Town with Nizhou Island. The main bridge is a double-tower, five-span steel box girder self-anchored suspension bridge, as shown in Fig. 1. The span of the bridge is 60 + 130 + 320 + 130 + 65 = 705 m, and the semi-floating structure system is adopted with a two-way six-lane arrangement. The ratio of the main cable to the span is 1:5, the theoretical sag of the middle span is 64 m, and the distance between the center lines of the main cable is 28 m. A single main cable is composed of 37 cable strands, and each cable strand is composed of 91 galvanized high-strength steel wires with a diameter of 5.0 mm, and the ultimate tensile strength of the steel wire is 1770 MPa. The standard distance of the sling is 12 m, and the bridge tower adopts the portal frame tower with a height of 117.59 m.

The 320 m long main beam of the middle span and 130 m main beam of the side span are arranged as steel box girders with slings, and the 60/65 m anchor span is arranged as steel box girders without slings. The steel box girder of the whole bridge is divided into class A segments such as A1-A17, B, C1, C2, D, E, F, G, H, I, J, and K, among which class A segment is the standard segment, D segment is the tower section, and G segment is the main cable anchorage section. There are 55 segments in total, including four beam segments for a single anchor, nine beam segments for a single edge, 25 beam segments for a middle span, one anchor beam segment, and one tower beam segment at the auxiliary pier position.

The stiffening beam adopts a flat streamline steel box girder, orthotropic slab bridge surface structure, the entire width of the cross-section is 38.5 m (including air nozzle), the standard beam height at the center line of the bridge is 3.5 m, and the steel beam height at the anchor section is uniformly transitioned from 3.5 m to 6 m. Iron sand concrete with a weight of 1000t is pressed on the steel beam at the anchor position of the main cable. The standard segment length is 12 m, the beam height is 3.5 m, the roof thickness is 18 mm, the bottom plate thickness is 14 mm, the outer web thickness is 16 mm, the inner web thickness is 14 mm, and the weight is 238.3 t. The standard section of the 1/2 main beam is shown in Fig. 2.

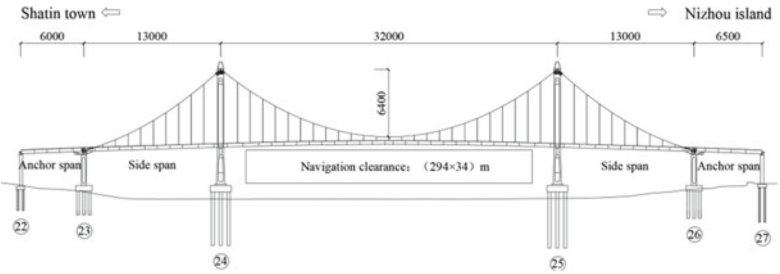


Fig. 1 South branch of Dongjiang River Shatian Bridge

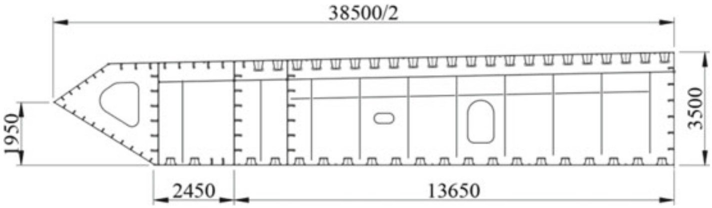


Fig. 2 1/2 Standard section layout of main beam

3 Overall Construction Technology of "Cable before Beam"

Shatian bridge construction adopted the "cable before beam" overall construction technology. Its main idea is to the temporary anchorage of the main cable temporary fixed, and then apply a similar mode of construction of suspension Bridges by anchor cable, main cable, and saddle, catwalks stiffening girder construction, stiffening girder hoisting, welding, after the completion of main cable release temporary fixed, transfer the main cable tension to the stiffening girder, complete system transformation. Temporary cables are set between the temporary anchorage and the main cable to form a temporary anchorage system to balance the tension of the main cable during construction. The overall process is divided into the following seven steps:

1. Construction of cable pylon, auxiliary pier, handover pier, and temporary anchorage, erection of tower area, side span, and anchor span range of beam support.
2. The steel beam of the tower area and anchor span is hoisted to the bracket of the retaining beam by a floating crane. It is slipped to the design position, pieced together into a whole, and the anchor is temporarily locked across the steel beam and auxiliary pier.
3. Install tower top gantry, hoist the main tassel saddle, install the hashing base, construction catwalks, install temporary cable, erection of the main cable
4. The main span is from the middle of the span to the cable tower, and the side span is from the anchor to the cable tower. The stiffening beam hoisting is carried out symmetrically, and the cable saddle pushing and temporary cable tension adjustment are carried out simultaneously during the hoisting process.
5. Hoist the closing beam section near the cable tower in the order of the first middle and second span, complete the construction of the stiffening beam closing, and weld each steel beam section.
6. Release the temporary lock between the anchor span steel beam and the auxiliary pier, relax the temporary cable, transfer the tension of the main cable to the steel beam, and complete the system conversion.
7. Carry out subsequent ancillary work such as asphalt paving, main cable winding wire, cat path removal, etc.

Typical overall construction process steps 3–5 of "cable before beam" are shown in Fig. 3(a)-(c).

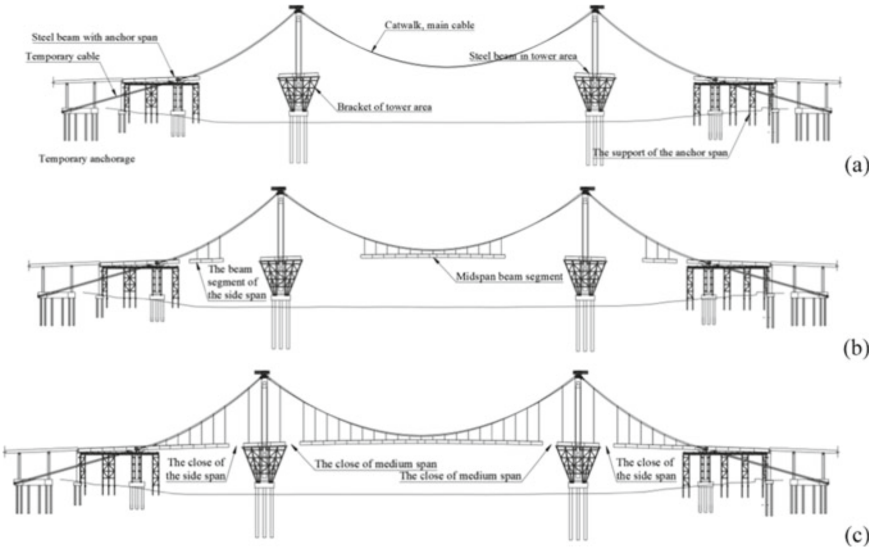


Fig. 3 Typical flowchart of overall construction technology of "cable before beam"

4 Key Construction Technology of "Cable Before Beam"

4.1 Permanent-Temporary Combined Temporary Anchoring System

The design of temporary anchorage system is the key to the construction technology of "cable before beam" for long-span self-anchored suspension bridge, which is directly related to the safety and economy of the whole project. The temporary anchorage system of this project is mainly composed of permanent-temporary combined with temporary anchorage and temporary stay cable, the main cable is anchored to the steel beam in the anchorage section, and the temporary stay cable connects the steel beam in the anchorage section with the temporary anchor as a whole, jointly bearing the huge main cable tension during the construction process. The site arrangement of temporary anchorage system is shown in Fig. 4.

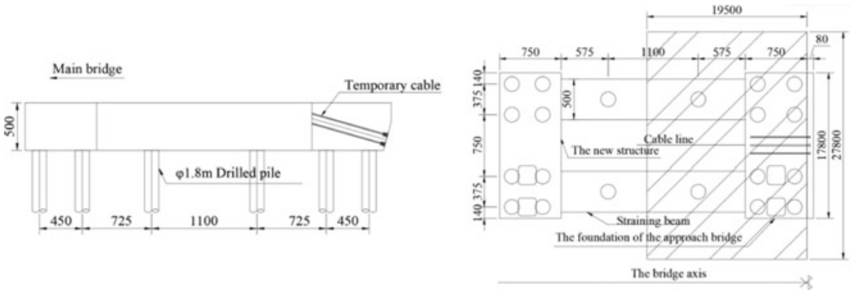
Temporary Anchorage. For this project, Huang Jianfeng [10] compared and analyzed three temporary anchoring schemes: independent anchoring, combined anchoring without increasing pile diameter and pile number, and combined anchoring with increasing pile diameter and pile number, and finally adopted permanent, temporary anchoring with increasing pile diameter and pile number from the aspects of force safety, economy, and construction convenience.

Vertical elevation and plan of temporary anchorage are shown in Fig. 5(a) and (b), in the implementation process, a single temporary anchorage uses the pile foundation and cap of the original approach bridge 20 and 21# (side of Shatian Town) or 28 and

Fig. 4 Site layout of temporary anchorage system

29# (side of Nizhou Island) and the new pile foundation and tie beam are connected between the two piers into a whole. The cap and tie beam together form a back-shaped structure, which improves the overall performance of the temporary anchorage. The plane dimensions of the whole temporary anchorage are 37.5 m long and 18.75 m wide, one for the upper and lower reaches of the bridge, a total of 8 piles for a single pier, and four root beam piles are added. The diameter of the approach bridge pile foundation is 1.8 m, the thickness of the cap is 5 m, the width is 7.5 m, and the length is 18.75 m. The newly constructed tie beam is 5 m thick, 5 m wide, and 22.5 m long. The diameter of the tie beam pile is 1.8 m, and the elevation of the pile bottom is the same as that of the bridge pier pile foundation.

The soil around the temporary anchorage is strengthened (as shown in the shaded part of Fig. 5.). High-pressure rotary jet grouting pile is used to handle the height below 7 m of cap mark, and filling is used to handle the height above the cap mark. The soil displacement rate in the reinforced range of high-pressure rotary jet grouting pile is 60%, the ordinary silicate water is 42.5 MPa, and the cement incorporation ratio is 25–30%. The unconfined compressive strength of the reinforced foundation soil reaches at least 1 MPa.



(a) (b)

Fig. 5 Temporary mooring arrangement plan

Temporary Cable. The main cable is anchored to the steel beam in the anchoring section, and the temporary cable is connected with the steel beam in the anchoring section to jointly bear the considerable tension of the main cable during the construction process, as shown in Fig. 6. A single temporary anchor cable is arranged in double rows up and down, left and right, with a total of 4 parallel steel wire cables. A single cable contains 301 galvanized steel wires of low relaxation and high strength with a diameter of 7 mm, and the standard tensile strength is 1670 MPa. Both the upper and lower piers are cold cast anchors.

A fork-shaped lug plate is arranged at the upper end of the temporary cable, which is connected with the lug plate reserved on the steel beam of the anchorage section through a pin. The anchor cup is set at the tension end of the temporary stay cable. The temporary stay cable passes through the reserved conduit hole of the temporary anchorage. It is anchored on the anchor plate at the rear end of the temporary anchorage through the nut. Figure 7(a) and (b) show the arrangement of temporary cable beam segment and tensioning end.

After the closing of the stiffening beam, the single-side main cable temporarily pulls the maximum pulling force, and the maximum pulling force is 2380 t. During the construction, the maximum horizontal deformation of the temporary anchorage is 17 mm. After the temporary cable is relaxed and the system is converted, it will return to the zero-displacement state.

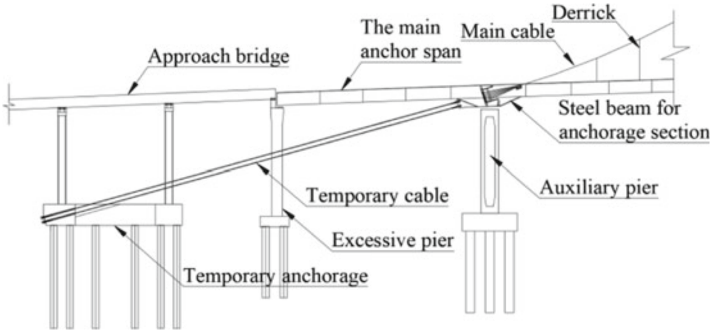


Fig. 6 General layout of temporary cable

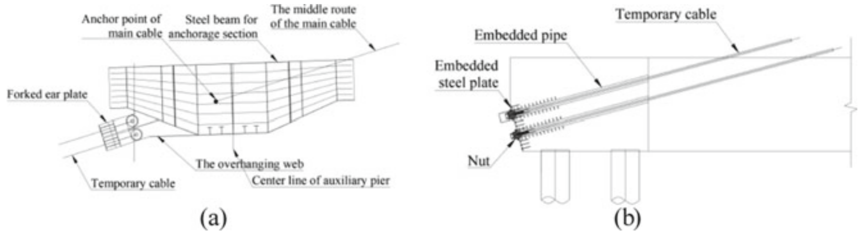


Fig. 7 Temporary cable beam end and tensioning end layout

4.2 Key Technology of Reverse Lifting Construction

Unlike the ground-anchored suspension bridge, the self-anchored suspension bridge has a sizeable carrier-span ratio, a slight stiffness of the main cable, and a large inclination Angle of the main cable. It is calculated that the inclination angle of the main cable is greater than 30° in the span of nearly 200 m during the hoisting of the main beam. According to the survey, the maximum working slope of existing cable-borne cranes in China is not more than 30°, and the conventional cable-borne cranes may not meet the climbing requirements. The input cost of a single set of cable-borne cranes is high. The erection of the main beam by cable crane has a large amount, an extended period, and the site construction is complicated, and the construction cost is high. The use of floating crane construction needs to cross the main cable, which requires high crane height, high requirements on the selection of floating crane equipment, and a long time to occupy the channel, great impact on navigation, and the economic benefits of floating crane is poor.

When the reverse lifting equipment carries out the main girder hoisting, the reverse lifting equipment is mainly composed of a temporary cable clip, anchor head seat, steel strand, continuous lifting jack, active coil of steel strand, pump station, and control operation table. The temporary cable clip is supported on the main cable to provide the anchor point for the reverse lifting equipment. The steel rope of the lifting jack is connected to the temporary cable clip through the anchor head seat. The typical arrangement of the reverse lifting condition is shown in Fig. 8.

Due to the short sling of the mid-span beam section and the large overall structure size of the reverse lifting equipment, the steel beam cannot be lifted to the designed height when the typical overall lifting arrangement is adopted. The bottom joists are designed to increase the distance between the main cable and the lifting point to meet the hoisting requirements of steel girders in the mid-span and short-span sling area. The bottom joist is designed with a non-through-length structure and anchored to the steel beam's bottom through two hinge points, as shown in Fig. 9. The design of non - the through - length bottom joist structure saves material, has a good economy, and is light weight easy to install.

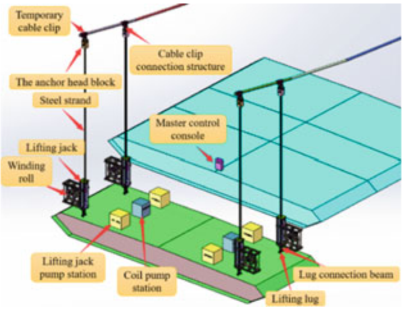


Fig. 8 Layout of typical working conditions of reverse lifting

Fig. 9 Short cable area reverse lifting arrangement

5 Key Control Technology of "Cable Before Beam"

5.1 Consolidating the Steel Beam of the Anchorage Section with the Auxiliary Pier

The main cable is anchored to the anchor section steel beam, which is installed on the auxiliary pier. The temporary cable transfers the reverse tension of the main cable to the temporary anchor by connecting the anchor section steel beam with the temporary anchor. According to the consolidation of the steel beam and auxiliary pier in the anchorage section and the tension mode of temporary cable during construction, it can be divided into two working conditions: 1. The anchor section steel beam and auxiliary pier are temporarily consolidated, and the increasing main cable tension is balanced by tensioning the temporary cables in batches during construction. During the process, the unbalance horizontal force of the auxiliary pier is too large, which affects the structure's safety; 2. The whole anchor span girder can move horizontally freely during the construction period. The steel beam of the anchor span is pre-skewed first. In lifting the beam, the main cable will be moved to the designed position due to the increase in tension of the main cable, and the cable will not be tensioned temporarily. In the process of moving with the steel beam, the cable will be passively increased to balance the increasing tension of the main cable.

The two schemes are analyzed and compared by finite element calculation. The consolidation scheme of the auxiliary pier balances the main cable force by tensoring the temporary cable several times, ensuring the maximum horizontal displacement of the auxiliary pier within 9 mm and ensuring structural safety. The unconsolidated scheme of the auxiliary pier and main beam reduces the tension times of the temporary cable. However, the displacement of the steel beam in the anchorage section is significant in the construction process, and the steel beam is active, so the temporary cable is passively stressed, and the force in the process is complicated. By comprehensive comparison, although the auxiliary pier consolidation scheme has more tensioning times, the stress is more apparent, more conducive to construction control, and safer, so this scheme is adopted. The comparison of consolidation schemes of piers and beams is shown in Table 1.

Table 1 Comparison of consolidation schemes of piers and beams

Main Analysis Results	Temporary consolidation	No temporary consolidation
Amount of saddle advance deviation	565 mm	900 mm
Number of saddle thrusts	3	3
Number of temporary cable tensioning	6	For the first time
Maximum horizontal displacement of auxiliary pier/steel beam	9 mm	361 mm

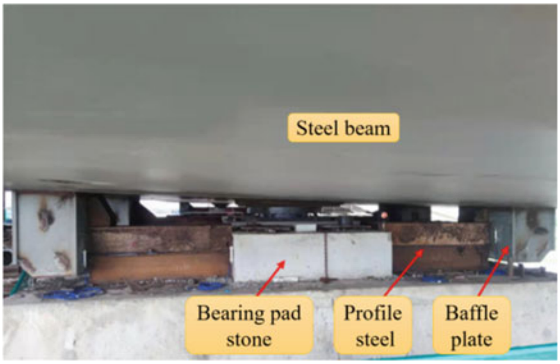


Fig. 10 Temporary consolidation diagram of steel beam and auxiliary pier in anchorage section

By welding the retaining block on the steel beam and using the shaped steel to resist the retaining block and support cushion stone, the steel beam and auxiliary pier in the anchorage section are temporarily consolidated, as shown in Fig. 10. During the construction process, the displacement of the auxiliary pier top is continuously measured to indirectly reflect the unbalance force of the pier top and observe the safety of the whole structural system.

5.2 *The Temperature Weld and the System Conversion*

Temperature Welds. After the steel beam hoisting is completed, the steel beam welding shall be carried out, and the temporary ground anchor system shall be converted to the self-anchor system after the welding is completed, which is the key to the whole construction control.

Steel beam welding is a continuous process, and many beam joints must be welded. Since the anchor section of the steel beam at the auxiliary pier has consolidated with the pier, the consolidation at the pier and beam should be relieved immediately after the welding is completed. Otherwise, the steel beam will cause excessive deformation of the auxiliary pier due to temperature deformation and cause structural damage.

In order to prevent structural safety problems caused by temperature deformation of steel beams during welding, welds between hoisted steel beams are divided into two types: conventional welds and temperature welds, and welded in a particular order, as shown in Fig. 11. After the completion of conventional welds, all temperature welds should be welded simultaneously, and the pier beam constraints should be lifted immediately after the completion of temperature welds.

The so-called temperature weld refers to the weld on both sides of the sealing section, and the width of the weld is 4 cm. The total length of the steel beam between the middle span closure section is about 280 m, and the total width of the temperature weld between the two closure sections is 16 cm. According to the temperature expansion coefficient of 1.2×10^{-5} line, the total width of the temperature weld can adapt to the temperature change of 47.6 °C of the 280 m-long steel beam in the middle of the span and meet the field requirements. The 4 cm wide weld can meet the requirements of the corresponding construction code after making the welding process evaluation test.

The setting of temperature weld can ensure that the steel beam welding process will not cause safety problems due to temperature deformation. At the same time, because the steel beam at both ends of the anchorage section is installed in the design position when the closing beam section is hoisted, the width of the closing gap can't be increased by pre-deflection. After setting the temperature weld, with the help of the surplus width of 4 cm at both ends and supplemented with pulling measures, the closing beam section can be successfully lifted.

The System Conversion. After the completion of conventional welding, temperature welding should be carried out at night when the temperature is stable. Due to the large seam width, large quantity, and heavy workload, it is challenging to complete at once. After the temperature weld web welding and the bottom laying and partial filling welding of the upper and lower bridge panels are completed, the auxiliary pier consolidation shall be lifted immediately, and the remaining welding shall be completed later. After all the welding is completed, the temporary cable is relaxed, and the system is converted. The temporary cable relaxation scene is shown in Fig. 12.

The specific construction steps are as follows:

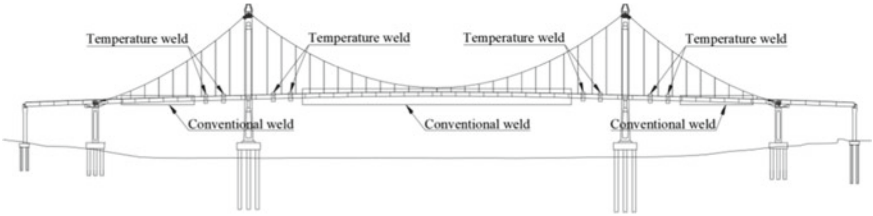


Fig. 11 General and temperature weld layout of Shatian Bridge

Fig. 12 Temporary cable scene relaxation diagram

1. Complete welding of other steel beam welds besides temperature welds. The middle span weld is carried out from the middle to both sides, and the edge span weld is carried out from the anchor to the tower;
2. Select a cloudy day with a stable temperature for the temperature weld's welding, and polish the temperature weld in advance to save time. After the temperature stabilized in the afternoon, a steel box girder code plate was constructed for eight temperature welds.
3. After the completion of the temperature weld code plate, all temperature welds should be welded synchronously at the time of the day when the temperature is stable (evening to early morning). First, the web welding, and then synchronous symmetric welding roof and bottom plate, complete the roof, bottom welding, and partial filling welding;
4. After the temperature weld is welded, the consolidation of the auxiliary pier will be relieved immediately. The consolidation of the auxiliary pier will be relieved before the temperature rises at 9 a.m., and the consolidation force will be small before the release through the deformation size of the bridge pier;
5. After the constraint of the pier beam is lifted and the construction of temperature weld top and bottom plate filling and the cover surface is completed, all welding construction of the steel box girder of the main bridge is completed.
6. After all welds are welded, the temporary cable is temporarily unloaded in stages, the stress system conversion of the superstructure is completed, and the load is unloaded in 13 stages. During uninstallation, ensure that the inner side and the upstream and downstream are uninstalled simultaneously.

5.3 Main Cable Slip Control and Cable Conduit Collision

Main Cable Slip Control. Since the rise span ratio of the self-anchored suspension bridge is more significant than that of the ground-anchored suspension bridge, it is difficult to control the slip of the main cable strand at the saddle position and meet the code's requirements by adopting the conventional erection method of synchronous edge-middle lifting. At the same time, the first beam segment of the middle span adopts the overall lifting form of large sections (three beam segments) with a weight of 637.6 t. However, the tension of the main cable is slight in the early stage, and the compressive stress reserve of the cable pylon is insufficient, which brings great trouble to the stress control of the cable pylon.

The slip of the main cable and the stress of the main tower can be solved by using water bags. When the safety factor of the main cable strand slip due to the increase of unbalance force does not meet the specification requirements and affects the force safety of the cable tower during lifting of the middle span beam section, water bag pressure is arranged on the installed beam section of the side span to adjust the unbalanced force of the main cable at the side span and middle span side. With the erection of the side beam section, the water bag is unloaded synchronously to reduce the unbalance force of the main cable on both sides of the saddle. The water bag pressure is used to solve the slip problem of the main cable strand in the hoisting process. The steel beam hoisting process is mainly simulated by the finite element method, and the trial calculation is carried out for each hoisting condition to determine the weight of water bag pressure so as to ensure that the slip safety factor of the main cable strand and the structural stress of each hoisting condition meets the specification requirements. The implementation of water bag pressure and weight on site is shown in Fig. 13.

Cable Conduit Collision. The diameter of the anchorage conduit of the suspension cable of the self-anchored suspension bridge is usually smaller, which makes the anchor plate safer and more reliable. However, the small inner diameter may easily cause the sling to bend at its anchorage conduit port during construction [11]. It has been mentioned in the construction of the Foshan Pingsheng Bridge, Guangzhou Liede Bridge, and Peach Blossom Valley Yellow River Bridge that a small cable anchorage conduit port will lead to a collision conduit port in the process of cable tension, resulting in more complex system conversion process. In order to avoid a collision, this problem is often solved by split-tension, which is also the difficulty in the conversion control of the "beam first and cable second" self-anchored suspension bridge system.

This project adopts "cable before beam" construction, and the sling is in place by one tension (installed to the stress-free length of the completed bridge). A temporary

Fig. 13 Implementation of water bag pressure on site

hinge connection is adopted between girder segments after steel girder lifting. In the early stage of erection, the bottom mouth of the steel box girder is in the open state, and the girder segment is significantly inclined. Especially in the middle span beam section, the two ends of the main beam tilt angle are more significant, and the sling collision cable conduit problem is more prominent; if no measures, the maximum impact force will reach 205 KN.

However, this problem is more prominent only when there are four pairs of mid-span slings in the early stage of erection, and there is no such problem when the line shape is smooth in the late stage of erection. For several pairs of slings at risk of collision, lengthen the derrick, increase the "sling length," put the main beam horizontally, reduce the angle of the trabecular section, and avoid slings colliding with the conduit port. As shown in Fig. 14, increasing the sling length by lengthening the derrick can significantly improve the collision problem. At the same time, a guide device in the shape of a horn is added to the cable guide opening, as shown in Fig. 15. The contact surface between the sling and the cable guide wall is enlarged to avoid scratching the PE sheath. In this project, except for four pairs of mid-span slings due to collision, the lengthening derrick is tensioned several times (to increase the length of the slings), and the rest are tensioned in place at one time.

Fig. 14 Maximum impact force of sling during construction

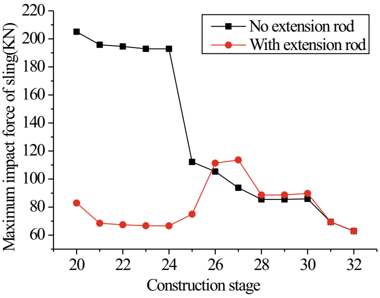


Fig. 15 Horn-shaped device for cable conduit

Conventional self-anchored suspension bridges usually adopt the construction technology of "beam before cable." For the need for suspension cable tension, the cable anchor box structure of the anchorage conduit and anchor plate is generally adopted at the lower end of the suspension cable, which will inevitably lead to a collision. For the self-anchored suspension bridge with the construction technology of "cable first and beam later," the design form of hinged suspension cable at the lower end of the ground-anchored suspension bridge can be used for reference to solve the above collision problems. The construction is not only efficient and convenient but also does not affect the appearance of the bridge. The optimization design in this aspect can be considered in the subsequent construction of similar projects.

6 Conclusion

The main span of Shatian Bridge is 320 m, and the river channel in the bridge location area is busy and close to the Pearl River Estuary's anchorage area. During construction, navigation closure (or traffic restriction) significantly interferes with local navigation and Taiwan prevention. This project abandoned the commonly used construction technology of "beam before cable" for conventional ground-anchored suspension bridges. It proposed the construction technology of "cable before beam" to realize the stent-free construction of the edge-middle span main beam.

In the construction process, permanent-temporary combined temporary anchorage is adopted. The stiffening beam hoisting adopts reverse lifting technology; For the short and medium-span sling area, the non-through-length bottom joists are designed. Temporary consolidation of steel beam and auxiliary pier in anchorage section; Temperature welds are arranged at both ends of the closing beam section; The water bag weight was used to control the main cable strand slip, and the sling length was increased by the extension rod to reduce the risk of collision between the sling and the catheter, and the horn-shaped guide device was added. These key construction and control technologies effectively ensure the smooth implementation of the bridge.

The bridge completed the system conversion in September 2021, and the construction process is progressing smoothly. The construction scheme of "cable before beam" is reasonable and feasible, which enriches the construction technology of self-anchored suspension bridges, further enhances the competitiveness of self-anchored suspension bridges, and can provide a reference for similar bridge construction in the future.

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