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# Construction management and technology innovation for main projects of Quanzhou Bay Bridge

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**Construction Contractor:** CCCC Second Harbor Engineering Company Ltd.  
**Supervisor:** China Railway Wuhan Bridge Engineering Consulting Supervision Co., Ltd.

## 1 Project overview

The new Fuzhou–Xiamen Railway of Lot 6 (Fig. 1) built by CCCC Second Harbor Engineering Company Ltd. is located in Quanzhou City, Fujian Province, passing through Jinjiang City and Shishi City and the Taiwanese Investment Zone. The Quanzhou Bay Bridge spans over Quanzhou Bay, with an axis distance of 85 m from the completed Quanzhou Bay Highway Bridge and pile number of starting and ending mileage of the contract section of DK148 + 566.12 ~ DK176 + 020.75. The route length is 27.455 km, covering bridge engineering, tunnel engineering, subgrade engineering and track engineering, of which there are 6 bridges (25.623 km) and 2 tunnels (608 m), 1.236 km of subgrade engineering, and 52.468 km of main track laying.

The project is characterized by long route, various types of bridge structures, extensive construction technology, novel management concept, novel bridge structure style (3 m × 70 m multi-connection continuous rigid structure without support), high quality target and standardization

requirements, high intellectualization and informatization requirements, high environmental protection requirements, large project scale, and multiple difficulties in terms of technology, management, and coordination between expropriation and demolition.

The sea conditions of Quanzhou Bay are complex, with the characteristics of semi-diurnal tides of large tidal range, windy weather, etc. The bridge area is busy with shipping and has a high level of safety risk for construction work on the water. The sea route of the bridge is 9.4 km long with 167 high piers in total in the sea, which is the most difficult and key project for the whole construction. A 9.4 km trestle and 167 construction platforms need to be erected, with a large amount of input of temporary measures. With great difficulties in construction, organization and technology, steel suspension box and steel cofferdam are used in the offshore foundation for bearing platform construction, while hydraulic climbing forms or turnover forms are used in the construction of high piers.

In the project, the technical concept of “advance planning, top-level design and consolidation step by step” is always maintained, and the dual brand of “Sea-Crossing High-Speed Railway Project” and “High-Speed Railway Sea-Crossing Bridge” is created from three major aspects of design optimization, process optimization and measure optimization, of which process optimization is combined with design changes, strengthening on-site technology and quality management.

## 2 Engineering construction technology innovation

### 2.1 Bridge engineering

#### 2.1.1 Factory prefabrication and installation of UHPC trestle panel

A 9.4 km steel trestle panel for the offshore construction of the Fuzhou–Xiamen Railway Project is made of ultra-high

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Fig. 1 Geographical location and route map of new Fuzhou–Xiamen Railway of Lot 6.

performance concrete (UHPC) (Fig. 2). UHPC is made of active dry mix, quartz sand, copper-plated steel fibers, water and high range water-reducing admixture in a certain proportion, and can minimize the defects within the materials by improving the fineness and activity of the components to obtain the maximum strength and excellent durability determined by the components. In terms of construction performance, UHPC has excellent workability, which makes it easy to operate and ensures uniform compaction. During the construction process, the working performance of the mixture is good and there is no loss of working performance for 1 h. The breaking strength and compressive strength of UHPC reach 26 and 150 MPa, respectively, which can meet the requirements of design indexes. During the implementation of the project, with the utilization of the UHPC material, technical support is provided for the project team and the problem that the steel trestle bridge was easy to be corroded by seawater is solved, thus saving resources and reducing costs.



Fig. 2 UHPC trestle panel.

### 2.1.2 Key technologies of single-wall steel suspension box construction in tidal areas

The bridge tower piers are located in the deep water area of Quanzhou Bay in the East China Sea, where the climate and sea conditions are complex, and the water depth is

influenced by the tides, so the design is complicated and construction conditions are hard. The steel suspension box is used as the water retaining and formwork structure during the bearing platform construction. The inner size of the suspension box is 5 cm expansion of the outer contour size of the bearing platform (26.6 m × 40.6 m), the height of the suspension box wall is 10.1 m, and the top and the bottom elevation of the suspension box are +7.475 and −2.625 m, respectively.

Considering the unfavorable working conditions, the assembled single-wall steel suspension box and the integral lifting construction method are adopted to quickly form the cofferdam structure; and taking into account of the condition of water level, the top seal concrete is poured in two stages, which effectively avoids the influence of complex marine environment and reduces the construction investment. The back-pressure brackets and circumferential reinforcement are installed on the steel casing to improve the bond stress of the top seal concrete. To improve the construction quality of the bottom seal concrete, the process of one layer of underwater construction + one layer of dry construction is adopted, and multi-layer connectors are set up to ensure the head difference between the inside and outside of the suspension box, while the water-collecting wells and blind ditches are set up at the bottom of the suspension box, so as to timely remove the water accumulated at the bottom of the suspension box, and to ensure the dry environment inside the suspension box.

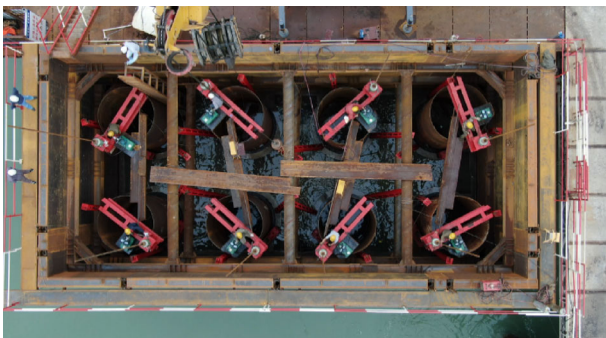
The overall construction process of the steel suspension box of the main pier of Quanzhou Bay Bridge is as follows: Steel suspension box is made in pieces and assembled → the steel suspension box is lifted as a whole by a floating crane and transported by barge to the site → floating crane is put into position as a whole, and the suspension system is installed → heaver plate is installed, and top seal concrete is poured → water in cofferdam is pumped, and the suspension system is removed → bearing platform and tower base are built → steel suspension box is removed (Fig. 3).



**Fig. 3** Lowering of the steel suspension box of main pier.

### 2.1.3 Construction process of bearing platform for the offshore steel-concrete suspension box

The construction process of steel-concrete suspension box of Quanzhou Bay Bridge is as follows: Wall and bottom plates are processed in pieces → prepare for construction of steel suspension box → assembly of bottom plate and wet joint pouring → assembly of steel suspension box → lowering of jack as a whole → tensioning rod stressing → grouting and sealing of bottom plate → water pumping in cofferdam → conversion of bearing system → bearing platform construction → removal of steel suspension box (Fig. 4).



**Fig. 4** Installation of lowering system.

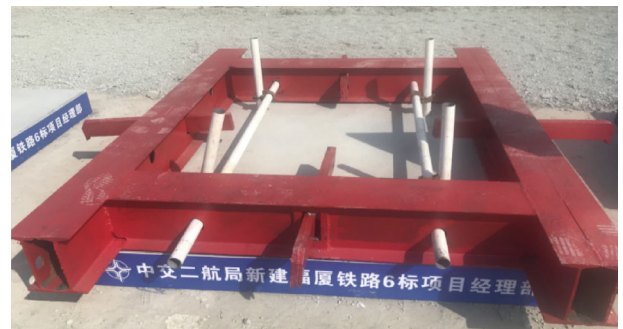
The processing of steel-concrete suspension box mainly includes wall structure processing and steel component processing. The steel-concrete suspension box is composed of 6 pieces of straight walls (size: 5.7 m × 8.15 m) and 4 pieces of corner walls (size: 2.85 m (lateral direction of the bridge) × 0.9 m (vertical direction of the bridge) × 8.15 m (height)), and the wall structure is processed in pieces on the section steel bed-jig. Compared with the traditional construction technology, the locking connection is used for the wall of unsealed steel-concrete suspension box, which has the characteristics of easy assembly and fast turnover, saving the amount of consumption of concrete and steel, avoiding the investment of large

water equipment and reducing the construction cost. This steel-concrete suspension box shows good values of economy, practicality and popularization.

## 2.2 Research and development of new techniques and construction methods

### 2.2.1 Multi-functional well frame for positioning of pile foundation reinforcement cage construction

The multi-functional well frame (Fig. 5) of pile foundation reinforcement cage is composed of well frame made of section steel, 4 movable cage-support plates, 4 vertical steel pipes on the main reinforcement of the cage, 2 horizontal steel pipes to prevent rising displacement and the connections between the pipes. The multi-functional well frame facilitates the steel cage docking during the lowering of reinforcement cage, and guarantees accurate vertical and horizontal positioning of the cage after lowering in place, which ensures that the cage does not deviate significantly. Meanwhile, the vertical steel pipe can effectively prevent the cage from rising displacement when pouring concrete, so as to ensure the accurate spatial position of the reinforcement cage in the hole position. At the same time, the well frame can be made large enough according to the diameter of each pile foundation, and the horizontal steel pipe holes can be reserved at different parts of the well frame to meet the requirements of different horizontal steel pipe positions corresponding to different pile diameters.



**Fig. 5** Multi-functional well frame.

### 2.2.2 Optimized method for formwork configuration of bearing platform

The method for formwork configuration of bearing platform is an optimization method specially designed for the uniform configuration of a large number of rectangular bearing platform formwork. It mainly makes use of the calculation program for overall consideration to plan the size of the bearing platform formwork and meet the size requirements during processing and construction,

so as to achieve the purpose of cost saving and convenient turnover. To be exact, the requirements for formwork configuration are transformed into calculation procedures, and the advantages of computer data processing are taken to screen and optimize a large number of configuration results to find the most suitable formwork configuration scheme that meets the requirements (Fig. 6). The method is applicable to rectangular bearing platform, and the larger the number of bearing platforms, the more the advantages, which can effectively avoid the problem of unreasonable formwork configuration and save costs.

### 3 Exploration of smart construction

#### 3.1 Tower crane safety monitoring system

The construction tower crane safety monitoring system can collect real-time machinery operating data through various sensors using the Internet of Things (IoT) cloud computer, wireless digital transmission and other new generation of information technologies. At the same time, the real-time data processing is performed in the information platform center for real-time monitoring and collection of operation safety performance indicators of construction tower crane, including lifting weight, hoist load, lifting torque, crane amplitude of variation, crane height, crane angle of revolution, tower tilt angle and wind speed in operating environment and other data; the voice warning and alarm can be sent when the rated limit value is approached, reminding the operator and management personnel to

pay attention to the crane in real time. The system can capture the conditions of in-service crane personnel in real time, send hazardous operation pre-warnings, send the push SMS of violation alarm to management personnel, generate machinery violation alarm data sheet, etc., so as to achieve data traceability. The system can effectively avoid and prevent the occurrence of safety accidents guaranteeing safety production, and vigorously promote the construction of the smart site of the project.

#### 3.2 Process control of engineering project and smart management of industry information base data

There are many structures in the project and the number of inspection batches, process control data files, construction logs, record sheets and other data is large. Taking pile foundation as an example, the number of inspection batches for it is up to 85575. The traditional process control and document management mode can no longer meet the demands of project management at this stage, as it is very difficult to collect, prepare and file data of various documents and information and there are many links and heavy workload in the site process control. Base on a survey, the Project Department has adopted DingTalk management system to effectively manage and control the quality and efficiency of document archiving, process control and batch data inspection for construction projects.

The biggest improvements are to enhance the work efficiency, save a lot of time from processing documents

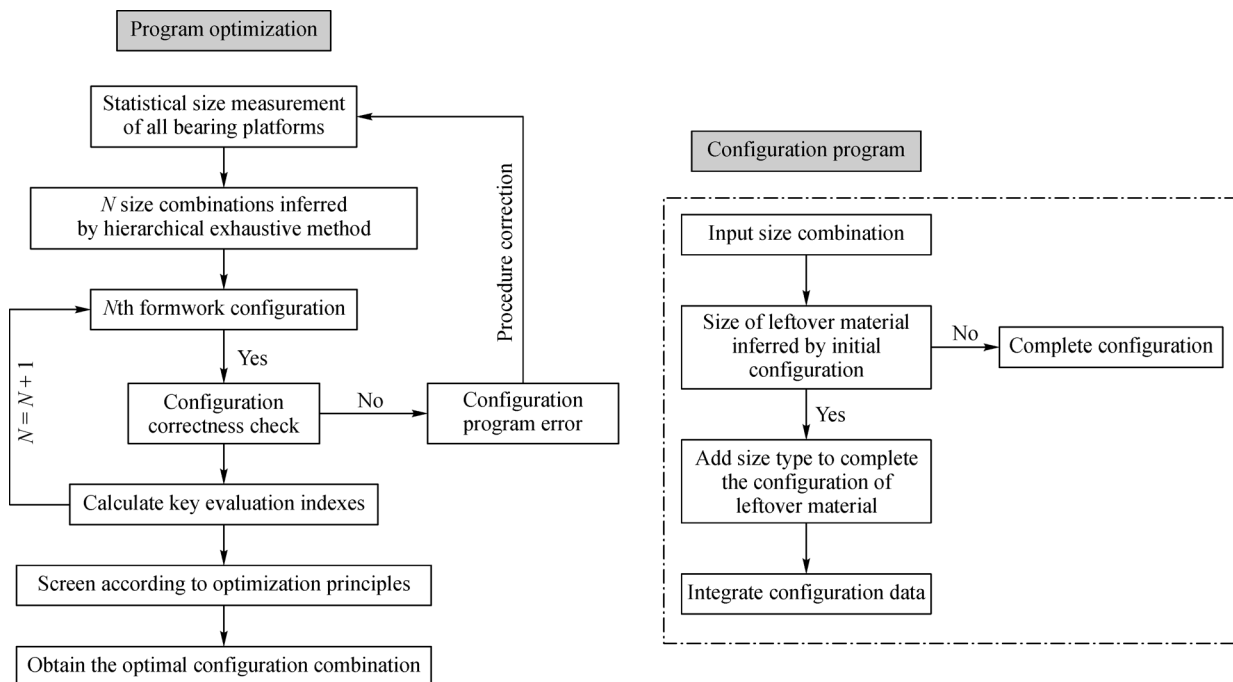


Fig. 6 Method and procedures.

and materials, and also avoid the waste of office supplies and the transportation and communication costs caused by repeated modification and printing, greatly reducing the workload of management personnel, thus achieving the purpose of cost savings and great improvement of work efficiency. At the same time, it builds bridges between the on-site technical personnel and the industry data personnel, so as to achieve better and more efficient communication and cooperation.

The process control and smart management of basic data of industry information mainly include the establishment of system to maintain order, clarify the division of responsibilities of personnel at all levels, document circulation, program review, document and information management, etc.

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## 4 Conclusions

With the completion of the main tower of the Quanzhou Bay Bridge, the construction of the Fuzhou–Xiamen Railway Project has entered a critical period. In the project, great importance is attached to technology innovation and specialization, standardization, digitalization and refinement of construction management, so as to make the project construction safer and more efficient with higher quality. With well design, careful organization, prudent construction and technology innovation, we break free from tradition, accumulate a number of representative scientific research achievements in construction and management, and finally build a project with high-quality and green, smart and culture characteristics.