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Research on Swivel Construction Technology of 22,400 Tons in Zoucheng Thirty Meter Bridge

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Abstract: In recent years, with the rapid development of highways and railways in our country, there have been many new bridges that need to cross the existing routes. If the conventional construction methods are used, the existing traffic will be affected and the traffic will be built above the busy traffic lines, so there is a big security risk, the construction methods must be improved and innovated. In this paper, it intends to research and develop some key technologies of swivel construction. According to the construction features to use finite element method of swivel cable-stayed bridge to analyse the cable-stayed bridge. The swivel construction process is carried out to solve the technical problems and difficulties in the construction.

1. Introduction

In recent years, with the rapid development of highways and railways in our country, many new bridges have emerged the problem that need to cross the existing routes. Using conventional construction methods will affect the existing traffic, and building above the busy traffic line construction is a big security risk, construction methods must be improved and innovated. The bridge swivel construction method is a construction process that can reduce or even eliminate hidden dangers though building at the side of the line, and it can bring significant social and economic benefits. Swing construction of bridges is a bridging craft which developed after the 1940s.

The slide and reasonable rotation system bases on the swivel structure in construction methods. According to the direction of rotation of the bridge structure, it can be divided into the methods of vertical swivel construction, the horizontal swivel construction (referred to as the vertical transfer method and the flat transfer method), and the methods of combining the vertical transfer and the vertical transfer. There methods have been mostly used in the arch bridge, beam bridge, cable-stayed bridge, slant leg rigid frame bridge and other different types of bridge superstructure construction.

Due to the fact that most of the existing bridges span the valleys, rivers and existing railways and highways, swivel construct method of the bridge is the best choice when choosing the bridge construction method. With the development of society, materials, equipment, theoretical analysis methods and test methods and other improvements, swivel construction method has been gradually applied to a variety of bridge type. Therefore, swivel construction technology in our country and foreign countries have a very broad application space and very ideal scientific research prospects.

For bridge construction, the emergence of each construction process will lead to a revolution in the bridge industry. The emergence of swivel construction technology has expanded the geographical scope...
of bridge construction and created a new idea of bridge construction – first. The bridge body is placed at a predetermined position, and then the bridge is brought to the designed position by a horizontal or vertical swivel. With the development of swivel technology, people are more and more realizing the great superiority of this technology. Especially when the construction conditions are severely restricted, the advantage of swivel construction is more obvious. Now, the swivel construction technology has been quite mature, from the mountain to the plains, from arch to continuous beam, continuous rigid frame and cable-stayed bridge, from highway to railway, from vertical to horizontal rotation and vertical rotation. The application of swivel construction is widely used.

2. Overview and Difficulties of Swivel Engineering of 30m Urban Railroad Crossing Bridge in Zoucheng City

Based on the rotary construction of 220,000 square meters of 30m bridge in Zoucheng City, this project is characterized by high difficulty, high technical content and high safety risk. Based on the research platform of the Bureau of Bridge, some key technologies such as rotary construction, bridge construction characteristics of cable-stayed bridges and finite element method, the numerical analysis of the rotary construction process of cable-stayed bridge has been carried out to solve the technical problems and difficulties in the construction process. Tonnage rotary construction projects provide reference and accumulated data and construction experience for the future.

Through the use of underground diaphragm wall construction to research and format the circular underground continuous wall seam partition and entered slot quality and suture treatment and construction of existing continuous diaphragm wall continuous wall construction safety and protection measures; In order to format the initial comments through the rotation system of the main study to test and control the Manufacturing precision, installation accuracy and rotating system. Through the construction of the main tower, the double girder cast-in-situ beams, the main prestressing tension parameters of the main tower, the control and testing of the stay cables, the line stress and weight control measures of the tower and the main girder are studied and formed. On this basis, research and development solve part of the construction of key technologies across the railway overpass.

3. Various technical research and implementation

3.1 Study on the Shielding Technology for Deep Foundation Pit of Main Piers

3.1.1 Plan selection

The deep pit support of the main pier cover belongs to the deep foundation pit construction near the existing line. The original design scheme adopts the enveloping method of "deep mixing pile + reinforced concrete retaining pile + annular beam", so the effect of sealing water is not particularly obvious. In contrast, the continuous beam retaining support platform excavation adopted the underground continuous wall protection scheme to ensure underground diaphragm wall protection structures prevent seepage and earth pressure resistance during excavation. When there is a large amount of water seepage during excavation, the method of non-drainage excavation and underwater concrete back cover can be effectively used to reduce the impact of the existing service line base. Excavation basic pit did not affect by the program does not set ring beam without internal support.

3.1.2 Ground wall construction technology research

1) The wall partition and slot into the order;
2) Wall construction technology into the key slot;
3) Construction process monitoring

3.2 Swing system design optimization and stress analysis and construction technology research

3.2.1 Swivel system design optimization
The original design of the bridge using the swivel structure ring and the central support combination as a turntable structure. The swivel structure of the swivel system consists of the lower turntable, the ball hinge, the slide way, the upper turntable and the rotating traction system. The lower turntable is located on the cap, fixed steel ball hinge which diameter is 4.2m. Setting on the turntable 8 sets of CFST legs supported on the turntable (cap) of the top of the concrete embedded in the ring road[2]. There are 12 sets of propulsion counter-bearing seats on the platform, two traction reaction seats and steel hinge lines on the turntable which is more than 4m in concrete, and turntable free end with QDCLT3500-400 continuous swivel jack Traction.

![Figure1 Booster system structure diagram](image)

The original system to promote the following shortcomings:
1) Installat difficulty. Before swivel construction, it needs to be installed in a small space at the slideway of the lower turntable, and the jacking jacks and reaction frames are removed. The operation space is limited and can not be assisted by a crane. It is very inconvenient to manually install it.

2) Uncontinuous operation. Starting swivel needs to quickly remove the booster system, due to the inconvenience of dismantling requires a lot of time, resulting in swivel pause is unable to continuous swivel.

3) Unsustainment. When swivel process is unexpected to stop, it needs to restart, it can not be boosted again because of the reaction seat and the position of the foot conflict.

Optimizing the system design of the help system: The help system only in the turntable to help pull the traction bundle, the traction reaction force set aside a hole 20cm in diameter in the traction reaction force to install the pull jacks to ensure it can be easy to construct.

Optimized to help pull system and its advantages are as follow:
1) Easier to install. Traction bundle embedded in the turntable at the next turntable through the traction reaction seat, construction space, drag jacks which can be used crane-assisted installation, convenient and quick.

2) Continuous operation. Stoping pulling the jack to supply oil without removing the help pull the top to starting swivel does not cause swivel pause.

3) Providing more room for operation and saving investment. With the help pull system, there is unnecessary to set up a propulsion reaction force seat, it provides more turntable construction operation space, and facilitate the construction of turntable and system conversion.

4) According to the need to adjust to help pull tonnage. Such as traction is greater, it just needs to adjust the number of embedded tow bundle and pull the jack tonnage.

3.3 Study on Construction Technology of Pylon in Construction with Pylon and Bridges on Both Sides

3.3.1 Main beam linear control
Main girder elevation control: After the girder bracket is erected, the support is pre-pressed, and the height of the pre-camber provided by the monitoring command is added to the elevation of the bottom girder mold of the main girder with adding the elastic deformation of the support; In order to ensure the cable duct installation location is accurate, vertical mold counter calculated the catheter installation coordinates, the installation of steel rigid frame with steel girder web reinforcement and welding.

Main girder structure size control: When forming the main girder, the structural dimension error of
the main girder must accord with the specification and design requirements. At the same time, the main girder and the transverse girder template should be reinforced to the slab (see Figure 2) to prevent the concrete pouring process in the mold.

![Figure 2: Side of the main box beams and beams template diagram](image)

Concrete segment weight control: Symmetrical pouring of concrete pouring records the corresponding section of the concrete side of the amount of error should be within the design allowable range;

Main girder line type monitoring: Temporary deformation measuring points are arranged on the main girder, three measuring point sections are arranged at the center of the girder longitudinal girder, and the rest of main girder structure is arranged every 5.3m point section which side across the cast-in-site layout of the three cross-section, each cross-section of the bridge arranged three temporary measurement points.

3.3.2 Pylon linear control
The main tower adopts hydraulic climbing construction. The main control point of the main tower is the deviation of the main tower and the size of each cross section. Specifically, it is used to control the deviation of axis and the control of cross-section dimensions when the model is reinforced.

The main tower linear monitoring: The main tower is divided into 11 sections, each section of the vertical alignment of the axis offset section size check concrete pouring after its review, the next section of legislation bases on the results of the previous section correction. Prisms are arranged on the top of the tower column to monitor the rotation of the tower and the tower top deviation in the state of bridge construction.

3.4 Finite element analysis of swivel construction process

3.4.1 Establishment of Finite Element Model
Before the establishment of the finite element model, the structure should be discretized and the discretization should follow certain principles. Otherwise, under the condition of equal precision, the model is not calculated too much time, the model and the actual structure are affected bad situation too far. In order to ensure the required accuracy of the premise, the original bridge structure is necessary to simplification, such as following simplification:

1) A cross-section of ancillary structures that takes into account only the cross-sectional shape of the main structure;

2) The use of soil spring simulation "pile a soil" effect;

3) The ancillary structure is not subjected to numerical simulation, but transformed into an external load applied to the structure corresponding position;

4) Considering the effect of longitudinal and vertical prestressing while neglecting the influence of roof transverse prestressing.

The Bridge Bridge and MIDAS / Civil software were used to establish the overall model of the cable-stayed bridge and to establish the construction phase of the simulation of the corresponding construction process, the two models of the calculation parameters, construction phase content and so on, in order to
check the results of each other.

Dr. bridge, double-column double-cable surface is equivalent to single-column single cable surface form it dose not consider the "pile one soil" effect and the bottom of the direct consolidation of the pier. According to the actual space position of the bridge structure and the actual structure size, using MIDAS / Civil to accurately simulate the space rod; the connection between the stay cable and the tower and the beam is simulated by the rigid arm element; the node elastic support simulation of "pile-soil" effect node. Bridge Doctor and MIDAS / Civil model structure diagrams are shown in Figure 3 and Figure 4 respectively.

![Figure 3 bridge doctor model](image)

![Figure 4 MIDAS / CIVIL model diagram](image)

From Table 1, it can be seen that the bridge state cable force optimized by the Bridge Doctor model and the MIDAS / Civil model are respectively within -7.09% -4.78% of the designed value within the acceptable range. In each construction stage of the two models, the girder and the tower column in the bridging stage tend to be more reasonable[5]. Therefore, the average of the construction cable forces iterated by the two models is taken as the optimal construction cable force value.

| number | design value | DB result | error value | MIDAS result | error value |
|--------|--------------|-----------|-------------|--------------|-------------|
| C1     | 2391         | 2345      | -1.92%      | 2345         | -1.92%      |
| C2     | 2240         | 2113      | 1.43%       | 2211         | -1.16%      |
| C3     | 2209         | 2226      | -0.80%      | 2228         | -3.16%      |
| C4     | 3147         | 3100      | -1.55%      | 3168         | -2.21%      |
| C5     | 2536         | 2488      | -1.80%      | 2513         | 1.94%       |
| C6     | 2736         | 2596      | 4.70%       | 2805         | -3.06%      |
| C7     | 2876         | 2763      | 4.05%       | 2946         | -2.56%      |
| C8     | 3012         | 2964      | 1.69%       | 3014         | -0.60%      |
| C9     | 3162         | 3202      | -1.26%      | 3121         | -2.15%      |
| C10    | 3380         | 3252      | -4.03%      | 3401         | -2.48%      |
| C11    | 3049         | 3061      | -0.49%      | 3043         | 0.29%       |
| C12    | 5687         | 3852      | -5.02%      | 3372         | -2.11%      |
| C13    | 2876         | 1890      | 1.96%       | 3712         | 4.13%       |
| C14    | 2876         | 1890      | 1.96%       | 3712         | 4.13%       |
| C15    | 4014         | 4000      | -0.02%      | 4023         | -0.41%      |
| C16    | 4130         | 4203      | -1.70%      | 4291         | -3.06%      |
| C17    | 4011         | 4096      | -2.09%      | 4061         | -4.85%      |

4. Conclusion
This project relies on the construction of the 30-meter-long-span railway overpass in Zoucheng City, it carries out the research on the retaining technology of deep foundation pit of the main pier cap, the optimization design and mechanical analysis of the swivel system, the research of construction technology, the construction of the main tower. According to the construction of cast-in-situ beam of girder support beam research of swivel construction technology and finite element analysis of swivel construction process, it forms a set of key technologies for swivel construction of large-scale overpass railway cable-stayed bridge. The research results are directly based on the project services to ensure the successful completion of relying on the project. All aspects of indicators to meet the design requirements, and effectively reduce construction costs.
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