Project Report

The Largest Space-Asymmetric-Curved-Single Tower Twisted-Cable-Plane Cable-Stayed Bridge—Tuojiang Bridge of Jinjianren Expressway Phase II Project

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Abstract: The Tuojiang Bridge of Jinjianren Expressway Phase II Project is located in Jianyang City and the Eastern New District of Chengdu, all the section length is 4.3 km with a total construction and installation cost of about 1.74 billion yuan. The road is classed as both a first-class highway and an urban expressway, with a design speed of 80 km/h for the main line and 40 km/h for the auxiliary lanes. Tongji University Architectural Design (Group) Co., Ltd. designed the main bridge which is an urban landscape bridge with a length of 963 m. The main bridge adopts $45 + 185 + 238 + 45m$ single-tower double-cable-plane cable-stayed span layout, and the approach bridge adopts prestressed small box girder structure.

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1 General Layout

The main bridge adopts $45 + 185 + 238 + 45 = 513m$ single-tower cable-stayed bridge, steel beam and steel tower structure, the tower and beam are rigidly connected. The main beam is 3.7 m high at the center axle, the standard section adopts the double-sided box structure, and beam adjoint the tower area adopts the closed full-box structure. The steel tower has a twisted space surface with a hexagonal section (Figure.1). The main pier adopts dumbbell type bearing platform, and 20 rock socketed piles with a diameter of 2.8 m are set under each platform. Double cable plane arrangement is adopted, and each cable plane contains 17 pairs of stayed cables, which are arranged according to the shape of spatial twisted cable plane (Figure.2).

Figure 1. Rending perspective view of Tuojiang Bridge

In order to reduce the free length of the space curved tower, the rigid connection system of the tower with beam is adopted. The V-leg and the main beam, and the tower foot is firmly connected with the tower base and platform through the anchor frame. The transition pier and the top of the auxiliary pier are set with spherical steel supports. Due to the special-shaped structure, the horizontal constraints of the supports will generate a self-balancing horizontal force in the structure system. In order to reduce the horizontal force under constant load, the longitudinal and transverse constraints of the supports are free sliding. At the same time, set the transverse elastic constraint, that is, set the transverse low elastic modulus rubber block and steel strand cable device between each pier and box girder, the transverse support reaction is mainly borne by the transverse rubber block, but also according to the transverse deviation of the beam end to adjust the tension of the cable, better coordinate the transverse displacement and the structure of the horizontal reaction.

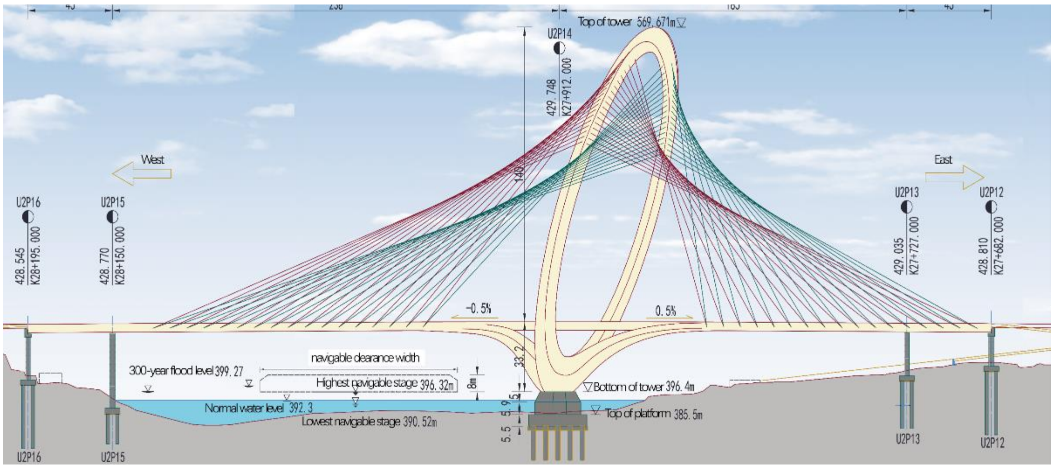

Figure 2. Layout of the main bridge

The standard cross section width of the main bridge is 64m: 2 × [6.0 m (slow traffic system) + 7.25 m (side lanes) + 4.5 m (side zoning) + 12.25 m (main lane)] + 4 m (middle zoning). The maximum width of the area near the tower is 85.5 m, and the dividing belt is arranged with green soil cover, ten lanes in both directions, and sidewalks and non-motorized lanes (Figure 3). The overall structure is large in volume, with high towers, wide deck, long spans and heavy loads.

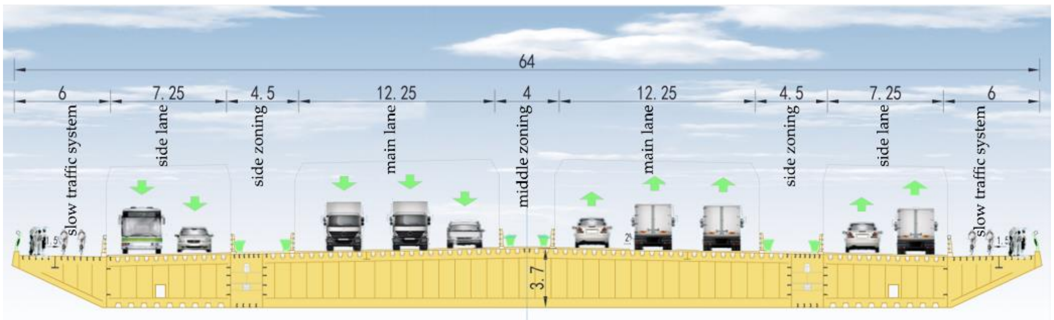

Figure 3. Cross-sectional layout

The structural asymmetry of the bridge is obvious, and the deformation of the structure under dead load is also asymmetric, showing a spatial deformation shape. The main beam and the main tower of the bridge need to set a spatial camber. Among them, the main tower should be reversely set three-way camber according to the deformation under the bridge condition, that is, the camber should be set in the transverse direction, longitudinal direction and vertically. The shape of the bridge tower is complex, and the setting of camber will increase some difficulty for the processing and manufacturing. By making appropriate processing and manufacturing plans, the accurate control of the shape of the bridge tower can ensure the smooth closure of the main tower. The camber of the main beam is also set according to the spatial curve, and the camber of different transverse positions on the same section is different. The camber value of tower and beam is closely related to the construction process. Combined with the camber value given in the drawing (the theoretical camber value of tower and beam once falling), the camber value should be corrected and adjusted according to the construction plan and the deformation of tower and beam in the construction process.

2. Construction stages

The box girder of the east main bridge is constructed with less support, the box girder of the west main bridge is constructed with pushing construction, the lower section of the main tower is suspended with crawler crane, the middle and upper section is suspended with large construction tower crane, and the main tower is constructed with less support + temporary cable anchoring scheme.

The main construction stages are as follows:

Step 1: cofferdam and trestle construction.

Step 2: simultaneous construction of the main tower foundation, tower crane foundation, steel box girder assembly platform construction.

Step 3: assemble tower crane, lower tower column construction, temporary pier of steel box girder under water construction simultaneously.

Step 4: simultaneous side span steel box girder lifting, main span steel box girder pushing assembly construction, steel tower segment assembly construction.

Step 5: After the main tower is closed, the support of the main tower is lifted and the cable is stretched.

Step 6: Carry out the construction of the whole bridge deck auxiliary facilities and adjust the cable force.

Step 7: The whole bridge is connected and ready for traffic.

Select the construction scheme of super large tower crane + less support + temporary cable bridge tower suitable for this bridge, and make full use of the tower column's own structure in the construction process, reduce the amount of support and reduce the amount of construction measures.

3 Cable related information

The cable system is the main bearing member in this bridge, and the load borne by the main beam is transmitted to the main tower through the cable. In order to ensure the safety, durability and convenient transportation and installation of the cable, the bridge uses the single wire coated epoxy-coated prestressed steel strand cable. The nominal diameter of epoxy-coated steel strand is 15.20 mm, and the tensile strength is 1860 MPa. The design life of the cable is 50 years, and its replaceable ability is taken into account.

The cable is required to have a high stress range of anti-fatigue performance, that is, the cable component in the stress limit of 0.45GUTS, stress range of 280 MPa, deflection Angle of 10 mrad (0.6°). After 2 million times of anti-fatigue test, the cables meet the requirements of broken wire rate ≤ 2%; The static load performance after fatigue can meet the requirements of minimum tensile force ≥ 0.95GUTS and elongation ≥ 1.5%.

The cable anchor is mainly composed of anchor plate, clip, supporting cylinder, nut, sealing cylinder, sealing device cable hoop, vibration damping device, PE tube connecting device at beam end and tower end, protective cover and so on.

The dynamic watertightness of the cable system meets the requirements of "Technical requirements for unbonded steel strand cabling" (JT/T 771-2009). HDPE outer sheath with wind and rain shock resistance function of double helix circular tube sheath (inner layer black, outer color), wind resistance coefficient CD ≤ 0.6.

During the installation of the cable, before the installation of the permanent vibration damping device, the temporary vibration damping device is installed between the cable and the main beam, and the permanent vibration damping device is installed after the construction of the bridge floor system. Cork is used to temporarily fix the construction process to avoid the vibration of the cable under wind load.

The pneumatic measures adopted by the stay cable can effectively suppress wind/rain vibration. The three-dimensional collision check of the space position of the cable has been carried out, and the non -collision problem of the cable under the sag effect has been considered. The collision has also been checked during the vortex vibration of the cable, and there is no collision problem. When the cable is buffeting, there is a possibility of collision caused by transverse vibration of the cable. Two measures are taken in the design. One is to use thermosetting PVF protective cover locally within 300 mm of the intersection point of the adjacent cable from No. 1 to No. 10 to prevent wear of the PE sheath. The contractor carried out special design and test of the protective cover to meet the effect of protecting the PE cable. The second is according to the actual space relationship and vibration of the cable after installation, choose to set the cable connector, and connect the adjacent cable at the nearest point to avoid collision.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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