Conceptual Design and Technical Response to a Tea-leaf Shaped Pylon of the 2nd Daxing Cable Stayed Bridge in Ya'an

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1. Introduction

The 2nd Daxing Bridge in Ya'an is a cable-stayed bridge which was designed to cross the Qingyi River in Ya'an, Sichuan in China. It is located 1km away of downstream of Daxing Bridge which is under construction. The preliminary design has been finished already and it is designed to be a landmark for the city. Taking local cultural symbol-tea and Ya Fish as the sources of inspiration, it uses separate double tower columns in the longitudinal which connected by transverse beams to form the tower as a whole spindle shape. General view of the whole bridge is shown in figure 1.

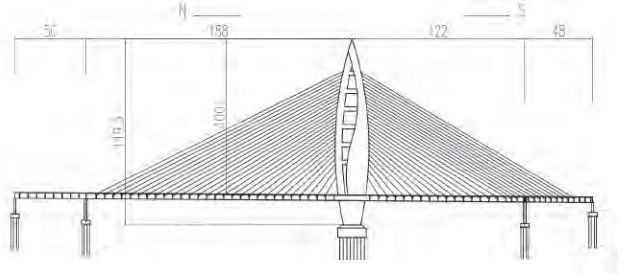

Fig. 1: General view of the whole bridge

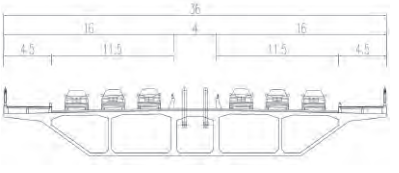

Fig. 2: Cross section of box gider

2. Conceptual design

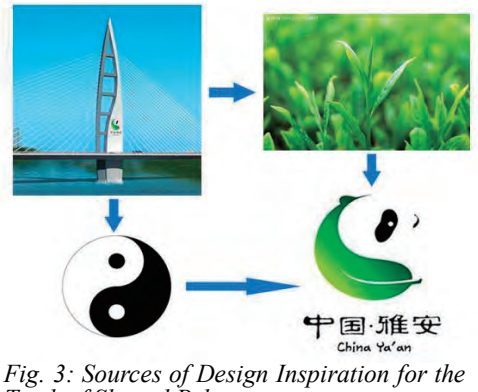

Fig. 3: Sources of Design Inspiration for the Tea-leaf Shaped Pylon

As a single pylon cable-stayed bridge, the shape of the pylon is the primary approach to reflect the design characteristics directly. During the conceptual design stage, we wanted to create a structure with a strong silhouette that at the same time would reflect the city symbol, and it should be easily read and understood by the onlooker. There were many culture elements of Ya'an, such as Hanjue, Ya fish and tea. We chose the tea-leaf as the main shape of pylon. The silhouette of pylon was spindle in the longitudinal while it was concise enough to be read as a tea leaf or the Ya fish and well expressed the city symbol. In order to visually look more three-dimensional, the pylon had variable cross-section with different width in transverse direction and looked like a sword. See figure 3.

For details of the shape of the pylon, we have adopted an asymmetric design, and integrated into China's unique cultural ideology - Yin and Yang. Two separate tower columns were arranged in the longitudinal. The north column was fine and the south column was much coarser with variable

cross-section. Multiple transverse beams were used to connect the columns to form a spindle shape. The size differences between two columns showed a visual impact in order to emphasize the union of virtual and actual.

3. Related special problems in detailed design of the pylon

For such a complicated pylon structure, using steel material would be an easy solution and more convenient for construction. But according to Owner's request for reasons of cost, we decided to use concrete as material to achieve the conceptual design of the pylon. It is obvious that the concrete 'Tai Chi' portion has significantly increased the stiffness of the south column of the pylon. The large difference of stiffness of columns has directly caused the vertical inhomogeneous deformation of columns under vertical component of cable forces.

Therefore, a compromised solution had been taken. We decided to use surface decorative materials as the 'Tai Chi' portion to maintain the symmetry of two columns. After completion of the construction of columns and transverse beams, thin steel plate will be made as 'Tai Chi' shape wrapping the south column. The steel plate was not directly involved in bearing the cable force as a part of the pylon, so it could be light enough to be attached on the south column and transverse beams with a few embedded parts. Symmetric arrangement of the columns has improved the stress state of the pylon, and the construction will be more convenient without considering the variable width of the columns in transverse direction.

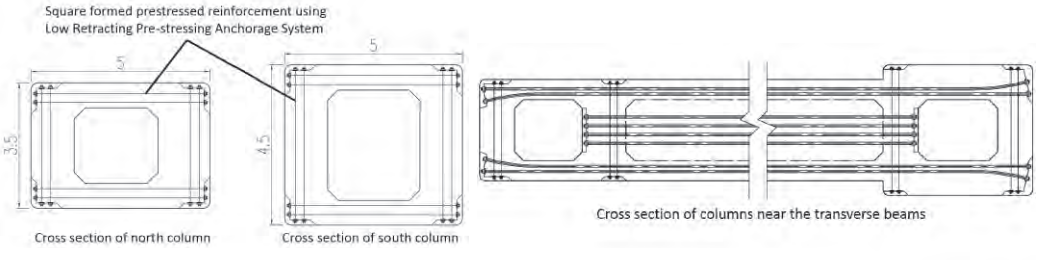

Fig. 4: Layout of prestressed reinforcement in columns and transverse beams

Applying sufficient prestressing in limited area of section to meet the stress condition as well as meeting the anchor space, construction tensioned space requirements would be the main challenge in design. Considering the effect of Poisson's ratio, the square formed prestressing need to be applied in the box section of columns. The final layout of prestressed reinforcement in columns and transverse beams is shown in figure 4.

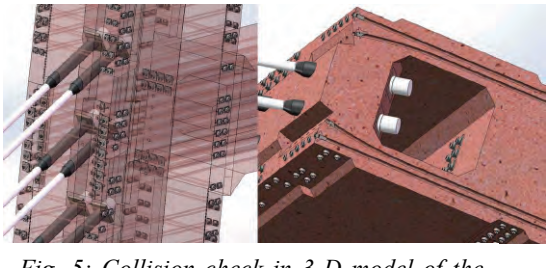

Fig. 5: Collision check in 3-D model of the pylon

In order to accurately determine the location of tendons in the structure, an accurate 3-D model has been built. See figure 5. We have run a collision check to ensure the sufficient space of each part has been reserved.

The geometry of the tea-leaf shaped pylon has its disadvantages for lateral aseismic performance, with the weight of the concrete girder was heavy, the structure was hardly conducive to earthquake resistance. Through the comparison of schemes and calculation, steel box girder scheme would be a more reasonable solution for the design. Reducing the weight of girder would be better way to improve the earthquake resistance of the bridge and at the same time maintain the aesthetic effect of the pylon.