RESEARCH ON A CFST TIED ARCH BRIDGE CONSTRUCTED BY INCREMENTAL LAUNCHING METHOD

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SUMMARY

This paper introduced a concrete filled steel tubular (CFST) tied arch bridge constructed by incremental launching method. The arch bridge (which span was 35m+120m+35m) was constructed on Shaoguan city, Guangdong Province, China, in 2003. Each foundation of this bridge was a single non-uniform section pile without bearing platform, the deck system were composed by two girders of single box and single room with tied bars in it, three circular CFST system were used in the main arch ring, and the suspension cables were a series of parallel wire cables. In the upper structure construction stage of this bridge, the deck system was constructed by incremental launching method, and then the main arch ring steel tube was constructed by vertical rotation method and the concrete of main arch ring was pumped along the steel tube, at the end, the deck system was connected with main arch ring by suspension cables. This construction method was applied to CFST tied arch bridge for its safety and economy, and was proved to a qualified construction method by a thorough detail inspection checks results in 2014 of this arch bridge.

Keywords: *CFST tied arch bridge, incremental launching construction method, vertical rotation construction method.*

1. INTRODUCTION

Arch bridges are constructed in many cities for its reasonable mechanical properties and beautiful shape. A CFST tied arch bridge (Wuliting Bridge) was constructed in Shaoguan city, an outstanding tourist city in Guangdong Province of China. The span of this bridge was 35 m + 120 m + 35 m, and it was constructed by incremental launching method, as shown in figure 1. For its beautiful shape, Wuliting Bridge has become a landmark of Shaoguan city. This paper will introduce some design innovations and construction innovations of this bridge.

2. DESIGN INNOVATIONS OF WULITING BRIDGE

Wuliting Bridge was constructed on a ring road of Shaoguan city, it has 505 m length and 30 m width, the main span of this bridge was a CFST tied arch bridge combined with prestressed concrete continuous girder, as shown in Fig. 1 and 2.

Fig. 1. *The photo of Wuliting Bridge.*

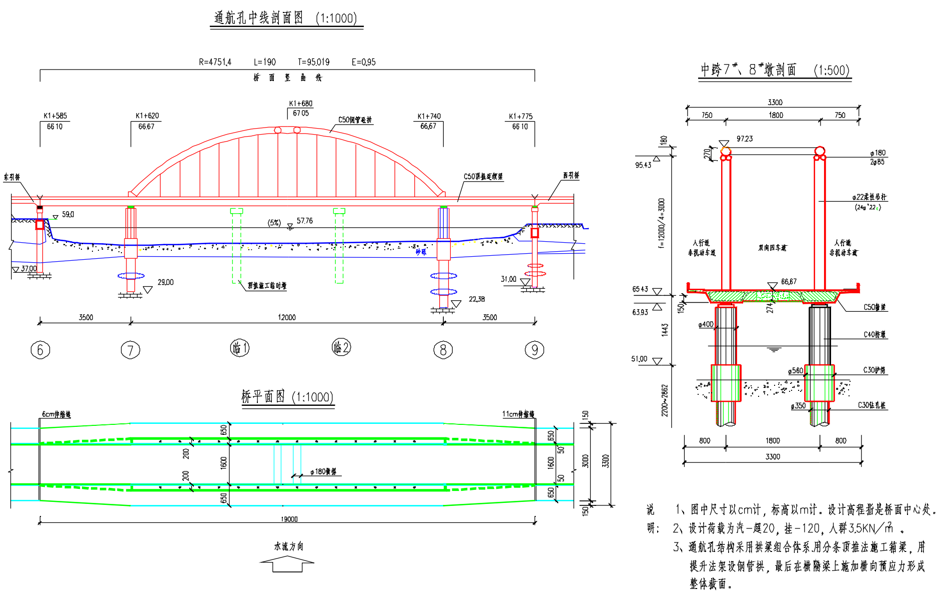

Fig. 2. *The design drawing of Wuliting Bridge.*

2.1. Tied girders

The tied girders of Wuliting Bridge were two single box continuous beams with 190 m length, 11.75 m width and 2.5 m height. The prestressed reinforcements of the girders were HM21-12, which prestressed forces were 3600 kN. In the upper of every single box, there were 18 HM21-12s with 64800 kN prestressed forces; in the bottom, there were 10

HM21-12s with 36000kN; the total prestressed forces of every single box were 100800 kN, and the prestressed forces of two single box were 161000 kN. In the tied girder construction stage, 161000 kN of 161000 kN was used for needs of incremental launching construction inner force; in the bridge operation stage, 100000 kN of 161000 kN was used for balance of CFST arch thrust forces, and rest 61000 kN of 161000 kN was used for needs of tied girders operation inner forces.

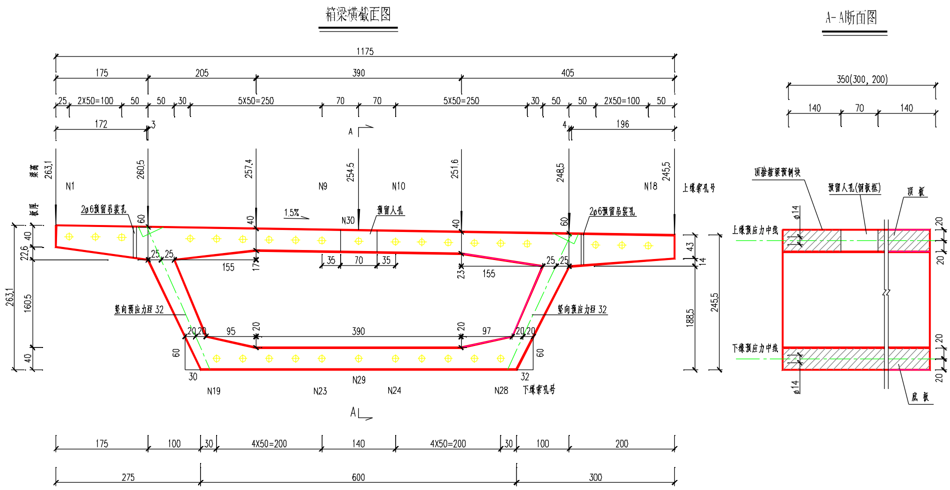

Fig. 3. The design drawing of tied girders.

2.2. Main arch ring

In this arch bridge, CFST material was used in main arch ring, for its construction convenience and high strength. Within all of CFST arch bridge, dumbbell-shaped cross section and truss were most commonly used main arch ring type. In Wuliting Bridge, a new main arch ring with three casts combined structure was proposed (as shown in figure 4), to solve out of plane buckling problem of this bridge. It was composed by two Φ0.85 m tubes at the bottom, one Φ1.8 m tube at the top and stiffened plate connection between three tubes. The out of plane buckling calculation results show that, this main arch ring has enough flexural-torsion buckling resistance, the safety factor K > 8 in construction process and K > 4 in operation stage.

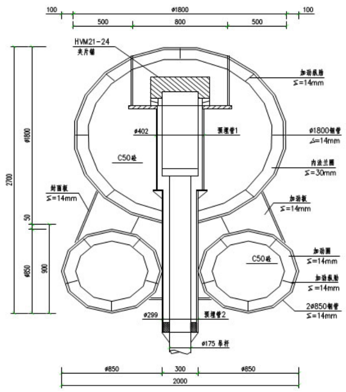

Fig. 4. *Cross section of three casts combined main arch ring structure.*

2.3. Substructure

In Wuliting Bridge, a non-capes variable cross section pier-pile combined structure was proposed for structural weight reduction. The diameter of piers was 4.0 m, while the piles had a variable cross section with three diameters: 5.6 m/3.5 m/3. 0m, as shown in Fig. 2. The pile with 5.6 m diameter part was open caisson used in construction stage, and 3.5 m diameter part was bored cast-in-place pile pierced through soil, while 3.0 m diameter part was bored pile embedded in bedrock.

3. CONSTRUCTION INNOVATIONS OF WULITING BRIDGE

3.1. Incremental Launching Method in Tied Girders

3.1.1. General situation

In this bridge construction stage, two tied girders was divided into six parts along bridge longitudinal axis, each part was 20-34 m box beam which was split into 8-9 box precast segments. Box girder casting yard was lied in the centre of approach bridge ground, and a 60 m steel truss beam was selected as assemble platform, as shown in Fig. 5. It taken 12-15 days to build up each box beam part, and average incremental launching speed was 3m per day, the time details was shown in Tab. 1.

Table 1. *Time spending of each box beam part construction.*

No.	Time Speeding [Day]	Construction Content
1	2	box segment lifting
2	3	reinforcement bar welding
3	5	concrete joint casting
4	2	prestressed construction
5	1	incremental launching construction
6	2	reserved time for unpredictable works

Fig. 5. *Box girder casting yard and assemble platform.*

3.1.2. Design of prestress

In Wuliting Bridge, a 7 Φ 7 parallel wires were selected as prestress, and HM were used for prestress anchor system, which include fixed ends, tension ends and a special connector between the fixed anchor and tension anchor; the fixed ends of this system were DM7-84 anchor, tension side were OVM21-12 anchor, as shown in figure 6. The Wuliting bridge construction practice shown that, HM anchors were suitable for prestress selection of incremental launching box beam.

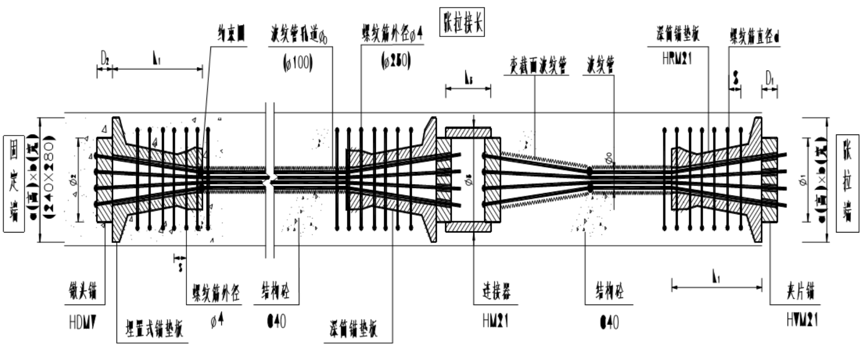

Fig. 6. *HM anchor system.*

3.1.3. Incremental Launching Process

In Wuliting Bridge incremental launching process, a 100 t continuous jack was installed in every pier, which can balanced box beam-pier friction resistance with its horizontal tension force. Using this method, the 190m continuous beam was incremental launched in 6 months, as shown in Fig. 7.

Fig. 7. *Incremental launching process of continuous box beam: a) photo of incremental launching, b) 100 t continuous jack, c) conctruction of steel tube main arch, d) slide equipment.*

3.2. Construction of beam arch combination bridge

After incremental launching of continuous box beam, steel tube can be constructed on the top of deck system, as shown in Fig. 7. In this bridge, bailey truss was used for support system, and steel tube was vertical rotated for main arch ring closure, at last concrete was filled in steel tube by concrete pump machine, as shown in Fig. 8.

Fig. 8. *Photo of main arch ring construction process.*

In this arch bridge, main arch ring and continuous box beam was connected by 28 suspenders, each one was composed by 18-7 Φ 7 parallel wires with 4900 kN inner tension force. After concrete filled steel tube main arch ring was completed, each suspender was tensioned to design inner force, thus box beam was lifted up and disconnected with construction temporary piers, as shown in Fig. 9. At the end, the concrete filled steel tube arch-box beam combination bridge was constructed.

Fig. 9. *Construction of beam arch combination bridge.*

4. CONCLUSIONS

Based on these design and construction innovations, Wuliting Bridge was constructed in 2003. After 11 years operation, the bridge was taken a thorough detail inspection in 2014. The examination results show that, this bridge is in good health conditions, and successfully resisted all of loads in operation stage.

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