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Composite Arch Bridges Developed in China

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Summary

This paper mainly describes the development of composite arch bridges in China.Three types will be demonstrated. The first is solid arch ribs composed of steel and concrete, second is arch truss ribs with their chord members composed by steel pipes and concrete , and third is reinforced concrete arch ribs or ring supported by composite arch truss structures in the construction and reinforced by the same one after completion. All these arch bridges are very successful, especially for the longest span RC arch bridge in the world.

1. Introduction

Within the years of recent decade, composite arch members used in Chinese highway bridge structures were specially successful. They were designed in different types, such as deck bridge, through bridge, half-through bridge and tied arch bridge, all with rise span ratio from 1/6 to 1/4. Most of the arch members are composed by steel pipes and filling concrete, and some are composed by stiff steel arch truss and the concrete arch rib or ring itself. All these composite arch bridges are mentioned in the following by some typical bridge examples.

2. Bridge with Two Solid Composite Arch Ribs

Bridges of this type are designed with two solid arch ribs composed by steel and concrete. The cross-section of each arch rib is shown by Figure 1, the vertically arranged steel pipes and two steel web plates with concrete filled both into the pipes and the space between two web plates and two pipes to form up as a dumb bell type. Between the two arch ribs some necessary bracings are arranged.

2.1 Examples of Through Bridge (Fig. 1)

The first example is Wang-Cang Bridge located in Sichuan Province. Over its main span is a tied composite arch structure with net span length of 115m and rise/span ratio of 1/6. Each composite arch rib is composed of two ∅800×10 mm steel pipes with center distance of 1200 mm and two steel web plates with thickness of 10 mm .The bridge width is 15 m, in which 7 m for two lanes of roadway , 2×3m for walkways and 2×0.8m for arch ribs. This bridge was opened in 1990.

The second one is Fo-Chen Bridge located in Guangdong Province. Over its main span is also a tied composite arch bridge with net span length of 110.3m and rise/span ratio of 1/5.The cross-section of each arch rib is more heaviver than that of Wang-Cang Bridge due to more wide it is. Each with two ∅1000×14mm steel pipes with center distance of 1500mm and two steel web plates of thickness 12mm .The bridge width is 26m, in which 17m for 4 lanes of roadway, 2×1.0m and 2×3.5m for arch ribs and sideways respectively. It was opened in 1994.

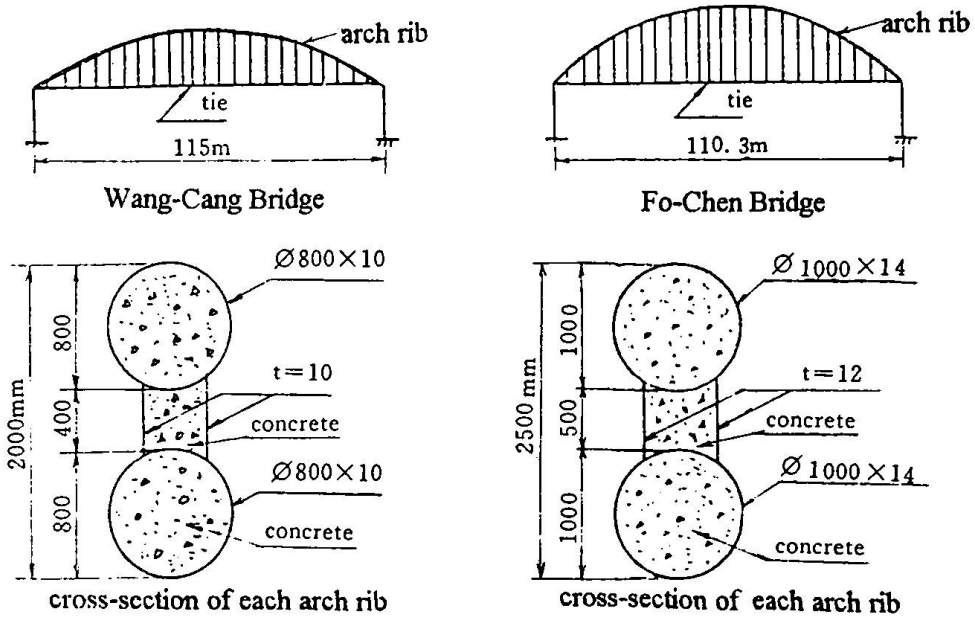

Figure 1. Wang-Cang Bridge and Fo-Chen Bridge

2.2 Examples of Half Through Bridge (Fig. 2)

The first example is Gao-Ming Bridge located in Guangdong Province. It is a two lanes bridge(12m wide only) with net spanlength of 100m and rise/span ratio of 1/4. Each arch rib is composed by two ∅750×10mm steel pipes with center distance 1250mm and two steel web plates with thickness of 10mm .It was opened in 1991.

The second one is Mo-Zi-Wan Bridge located in Chengdu City , the capital of Sichuan Province. This bridge is now under construction with net spanlength of 120m and rise/span ratio of 1/5.5. Its arch rib is designed to use two ∅800×12mm steel pipes with center distance 1200mm and two steel web plates with thickness of 12mm . Its total width is 7.5 m only with 7m for two lanes and without walkways.

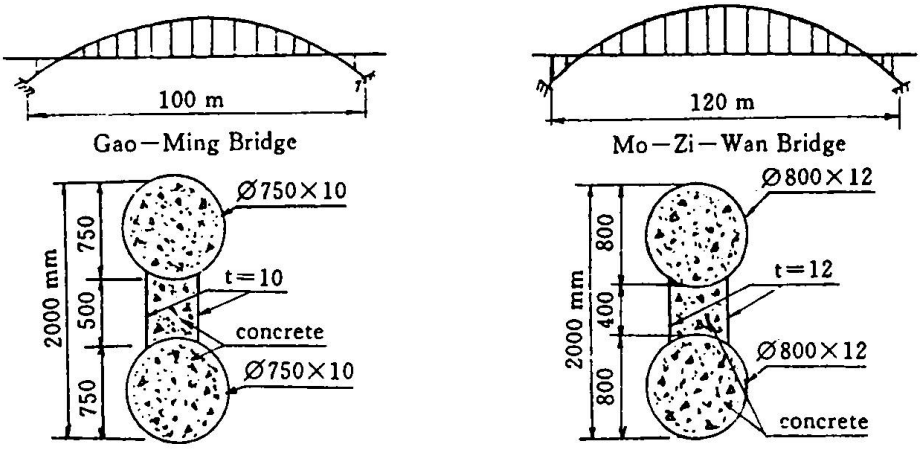

Figure 2. Gao-Ming Bridge and Mo-Zi-Wan Bridge

3. Bridge with Two Composite Arch Truss Ribs

Bridges of this type are designed with two composite arch ribs and some necessary bracings between the ribs.Each composite arch rib is composed of 4 steel pipes arranged at 4 corners of a rectangle or trapezoid and some web members and horizontal members. 4 steel pipes with filled concrete perform the 4 composite chord member of the arch truss rib.

3.1 Examples of Through Bridge (Fig. 3)

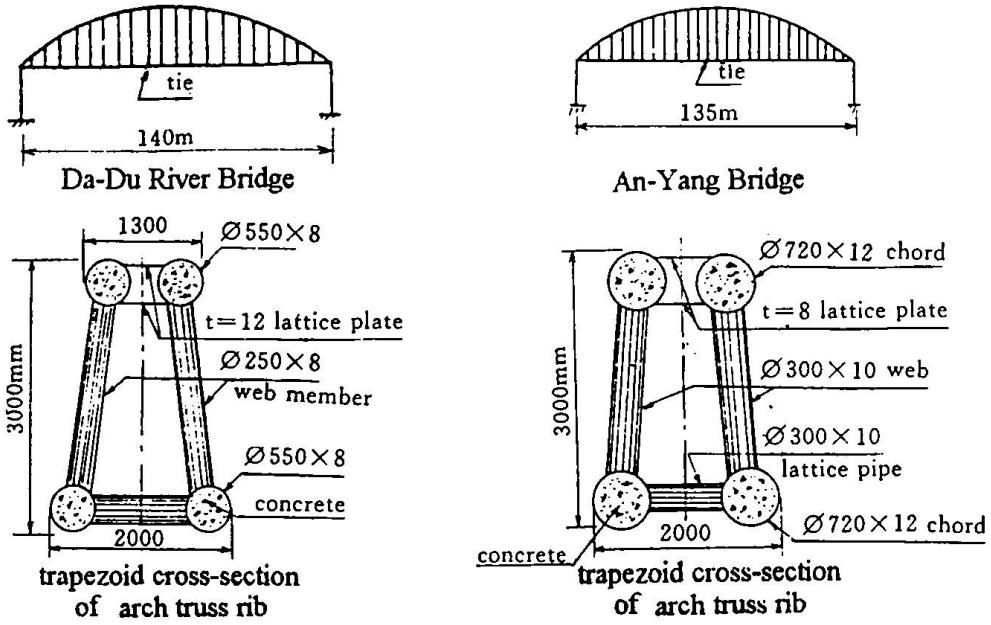

Figure 3. Da-Du River Bridge and An-Yang Bridge

The two examples are Da-Du River Bridge located in Sichuan Province and An-Yang Bridge located in Henan Province with net spanlength 140m and 135m respectively, and both the rise/span ratioes are 1/5 . Each composite arch truss rib is composed of 4 corner steel pipes filled with concrete performed as both upper and lower chord members , their web members are made by hollowed steel pipes, as well as the horizontal members between the two lower chords, two horizontal lattice plates are used to connect the two upper chords.The total width of bridge deck are 13m for 2 lanes and 31m for 4 lanes respectively. Therefore , the composite arch truss rib of later is heavier than the former.The detailed dimensions of their trapezoid cross-section are shown in Figure 3 respectively. Da-Du River Bridge was opened in 1995 and An-Yang Bridge is under construction.

3.2 Example of Half-Through Bridge (Fig. 4)

The San-Shan West Bridge located at Nanhai City in Guangdong Province is an example of this type.It is a half-through tied arch structure with the spanlength arranged as 45+200+45m.The rise/span ratio of the central arch is 1/4.5.Total width of the bridge deck is 28m ,in which 15m for express way,2×3m for trucks and 2×1.5m for pedestrian. Each composite arch truss rib is composed of 4 steel pipes located at 4 corners of a rectangle and both the hollowed steel pipe web membes and double horizontal plate members. Concrete is filled both in 4 steel pipes and the spaces between double horizontal plate upper and lower .Detailed dimensions are shown in Figure 4. This bridge was opened in 1995.

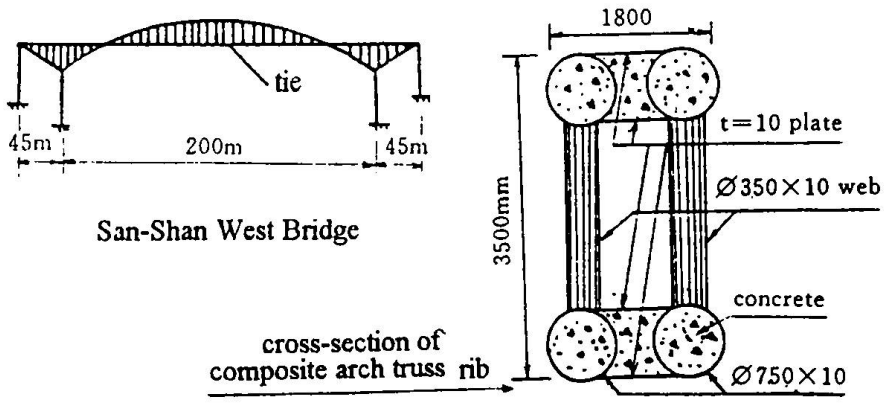

Figure 4. San-Shan West Bridge

4. RC Bridge with Composite Arch Truss Ribs or Ring Acted as Support System in Construction and Stiff Reinforcement after Completion

For this type of bridges,composite arch truss is designed first to support the concrete arch structure in construction stage, and then to be composed by the former and later,and performered a role of reinforcement of the permanent arch structure. The composite arch truss can be both in the types of two ribs and one ring.

4.1 Examples of Half-Through Bridge (Fig. 5)

In 1993, a half-through arch bridge named New Lon-Ao with net spanlength of 117.8m and rise/span ratio of 1/4 was completed and opened to traffic .Its total width 22m is composed of 0.5+9.75+1.5+9.75+0.5m for dual 3-lane of roadway.Two arch ribs each was first erected by a arch truss rib with 4 steel pipes of ∅300×13mm as its chord members ,and then concrete was filled into pipes to form up a composite arch truss structure, subseqently this structure played a role as support system to take the weight of concrete arch rib with the cross-section in rectangular box type , and finally it was embeded in the concrete arch rib as its stiff reinforcement.

In 1995, another similar bridge named Luo-Guo was opened over the Jinshajiang River in Sichuan Province with a more longer net spanlength of 160m and rise/span ratio of 1/4. Compared with New Lon-Ao Bridge ,the diagonal hangers are changed to vertical, and the depth of arch ribs is increased from 3.0m to 5.4m,and the thickness of flanges and webs is increased from 34 to 37cm and 30 to32cm respectively, also the deck width is decreased from 22m to 15m .The construction method and other structure arrangement have no any change.

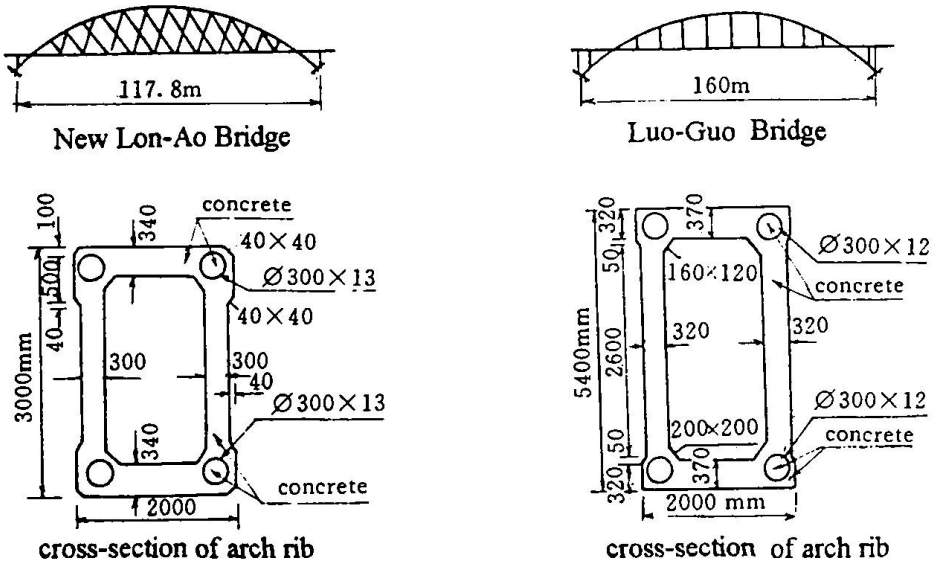

Figure 5. Lon-Ao Bridge and Luo-Guo Bridge

4.2 The World's Largest Span RC Arch Bridge (Fig. 6)

Wanxian Yangtze River Bridge is now under construction and will be soon completed at July of 1997.This bridge with net spanlength of 420m will be the longest one of RC highway arch bridge in the world.It is a deck arch bridge with rise/span ratio of 1/5 and total deck width of 18m , in which 15m for 4 lanes of roadway and 2×1.5m for walkways. The cross-section of the RC arch ring is a 3-cell box with 7m in depth and 16m in width.

The first work was to erect a stiff steel arch truss ring which is composed of 5 plane-truss with spacing of 3.8m from each other. The depth and width of this steel arch truss are 6.45m and 15.2m respectively .10 ∅400mm×16mm seamless steel pipes are used for upper and lower chord members .All web members and bracings are made of shape steels. After the steel arch truss ring was closed at its crown, pumping concrete was then filled into the 10 steel tubular chord members to form up a very stiff composite arch ring structure.

The whole cross-section of the concrete arch ring is divided into7 areas and cast in 7 steps .The stiff composite arch ring was used to support the weight of concrete cast in the first step.The composite arch ring structure composed of the stiff composite arch truss ring and the first area of concrete arch ring was then used to support the weight of concrete cast in second step, and similarly, the concrete cast in No.n step was supported by a new composite arch structure composed of the stiff composite arch truss ring with (n-1) areas of concrete arch ring. The whole concrete arch ring will be thus cast step by step until the whole composite arch truss ring will be embeded in the concrete as stiff reinforcement.

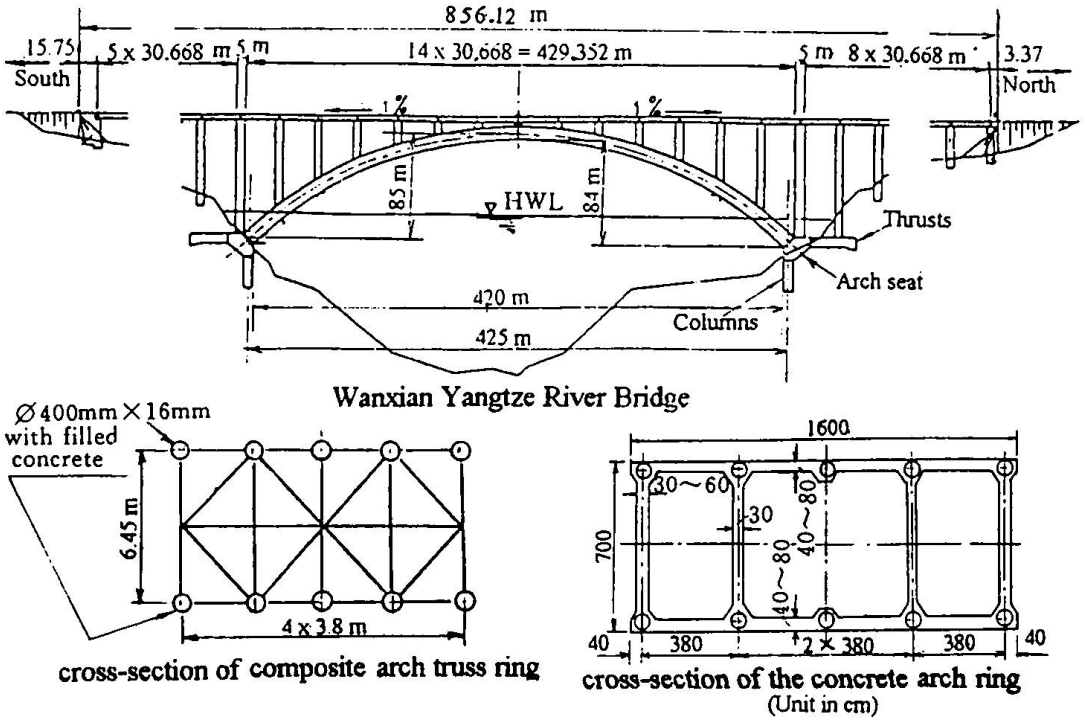

Figure 6. Wanxian Yangtze River Bridge

5. Conclusion

Construction of the Wanxian Yangtze River Bridge was commenced at May 1st of 1994,and it will be hoped to be opened at July, 1997. It may be said that the composite arch bridge developed in China is very interesting and successful.