

Aesthetics conceivability and structural characteristics of Dagu Bridge

Zhendong Ma

T.Y.Lin International China , Chongqing, China

ABSTRACT: Design of bridge scheme shall incorporate aesthetics and local economic & cultural characteristics. Proper bridge type shall be selected and breakthrough of the scheme for the bridge type shall be pursued possibly. Dagu Bridge shall be not only a bridge but also a monument even one artwork. The moral of the design scheme means that the golden dragon is dancing while either Sun or Moon is shining. Two inclined arches, one is big and other is small, symbolize Sun and Moon respectively. Sufficient space shall be available for people to enjoy water scene. Here is a tourism attractor. The transverse rigidity of the deck and the vertical rigidity of the arch are both fully utilized so that a quite sylphlike structure could be available and also it can resist the strong earthquake in Tianjin region.

1 CONSTRUCTION BACKGROUND

There is a legend of 72 Gu (means rivers) in the history of Tianjin due to lots of water systems here. Many place names in Tianjin are related to Gu. Dagu is one of them. The Haihe River is the original place of Tianjin City. It is the unique and landmark valuable resource as well as raises thousands of millions of Tianjin people.

The Dagu Bridge is a typical urban bridge in downtown (Fig. 1 and 2). It is the geometric center of Tianjin City and located on the Haihe River which is the boundary of Heping District and Hebei District. The bridge connects Wujing Road in Hebei District and North Dagu Road in Heping District. One end of the bridge is the scenic spot with Italian style and the other end is the most flourishing commercial street of the City.

As a key project of the comprehensive development construction on both banks of the Haihe River, Construction of Dagu Bridge is required to apply new technology and new techniques. Besides the bridge functions are satisfied, the landscape effect of the bridge shall be strongly displayed so as to have it work as a symbolic building.

The Dagu Bridge will be not only a unique landscape on the Haihe River but also practically merged into the new image of the Bingshui central commercial zone and the new landscape & commercial activities of the Bingshui citizen square around of Tianjin.



Figure 1 : Project Location



Figure 2 : The Haihe River

2 DESIGN CONCEIVABILITY OF SCHEME FOR THE BRIDGE LOCATION AND TYPE

2.1 Limitations on type selection of Dadu Bridge

Limited clearance of navigation of the Haihe River and limited height between elevations of the ground and the river surface;

- (1) Piers are not allowable in the watercourse of the Haihe River;
 - (2) Soil on both banks is soft in geology;
- Protection from strong earthquake of eight degree in Richer Scale is required.

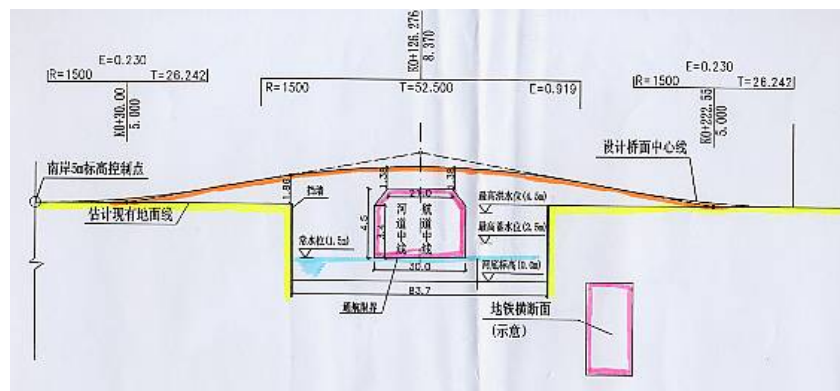


Figure 3 : River layout

The first two factors above-mentioned restrict the height of the main girder. The height of the main girder in the middle of the spans over the navigation watercourse is 1.38m only after all geometric conditions are satisfied. The river section where Dadu Bridge is located is 96m wide approximately. All girder bridges top-bear arch bridge and half-through arch bridges all are not feasible if one span is applied to overfly the river due to the long span and the lower girder height. If pier is built in the middle of the river, 30m wide deck with short span cannot satisfy the requirement of beautiful shape and could not be a landmark bridge. Therefore, pier should not be arranged in the watercourse.

Soft soil on both banks is unfavorable to establish ground anchor of suspension bridges or apply the flat-arch girder with large thrust. Provided that these two bridge types are applied, a couple of pile groups with high cost shall be demanded. So, these bridges are not feasible in term of economy. On the other hand, the flat arch with limited height of the main girder of the middle span is unfavorable in term of the structural safety under the condition of strong earthquake force.

Therefore, the feasible bridge types include the through arch bridge, truss bridge and cable-stayed bridge. The truss bridge cannot satisfy the requirement of beautiful shape and the cable-stayed bridge with length less than 200m is not economic. Because the height of the main

girder is too small, Concrete structure will quite difficult. In order to reduce the self weight of the bridge and satisfy the requirement on design of protection against strong earthquake, the steel bridge is the best choice.

Comprehensively, the through tied arch bridge is the suitable scheme with considerations of construction conditions, proper arrangement, rational cost and landscape coordination.

2.2 Principles for Proposal of Bridge Type Scheme

- (1) Satisfy requirements on the bridge functions;
- (2) Strongly outstand the landscape effect of the bridge so as to have it work as a symbolic building.

Four basic requirements on bridge must be satisfied: safety, applicability, economy and beautiful shape.

Peoples of the City expects Dagu Bridge not only a bridge to lead traffic but also a bridge with high tourism value, an artwork and one of symbolic buildings in Haihe District.

2.3 Scheme and Aesthetics Conceivability

- (1) Mutual movement of city, river and bridge

The bridge satisfying four requirements on bridge may not satisfy the bridge expected by Tianjin City.

When Dagu Bridge is designed, you should think it is a monument, a beautiful artwork or a symbol of Tianjin or at section of the Haihe River in urban area rather than a bridge only. So, the beautiful shape is not enough. It must be an elegant structure, an innovative building.

Most famous cities in the world are well known internationally because of their symbolic rivers and structures over these rivers such as the Seine River and Alexandra III Bridge in Paris, the Thames River and Millennium Bridge in London, etc, see Fig. 4 to 8. The Danube River in Vienna, the Main River in Frankfurt, the East River in New York, the Neva River in St. Petersburg all of them are sprinkled by beautiful bridges. The Zhaozhou Bridge in China, of course, ranks the top of them.



Figure 4 : Alexandra III Bridge



Figure 5 : Millennium Bridge

These rivers and bridges over them make these cities more lingering charm. If the Haihe River in Tianjin can be utilized fully, The city will also grow more beautiful and more lingering charm.

These bridges can be classified roughly into two types: one is famous for its history such as Alexandra III Bridge in Paris, Tower Bridge in London, etc. The other is well known for its technical achievement and excellent shape such as Millennium Bridge in Britain, Golden Gate Bridge in San Francisco, Alamillo Bridge in Seville, Spanish, etc.

It's lucky that Haihe River is in Tianjin. Dagu Bridge must be built in terms of applicability and more beautiful shape. It must be such a quite different bridge that could increase the city landscape.

- (2) Selection of bridge type---modern or classical

At the beginning of the new millennium, modern bridges shall be built. This is also the tendency of most famous cities in the world. For example, the Louvre Museum, Solferno Bridge over the Seine River, and Millennium Bridge in London, etc, all of them are modern buildings. Application of the most modern bridge type is rational when a bridge is built over the Haihe River.



Figure 6 : Alamillo Bridge



Figure 7 : Tower Bridge



Figure 8 : Modern structures

2.4 Scheme Design

An new bridge type is selected for Dagu Bridge according to the actual situation: Riyue Arch Bridge (Riyue means the sun and the moon). Its moral is that dragon is dancing while the sun and the moon both are shining.

The Haihe River development project is named the golden dragon dancing. Mr. Man-Chung Tang, developed one new bridge type and named Riyue Bridge. It outstands the moral of the golden dragon dancing. Two inclined arches, one is big and the other is small, represents the sun and the moon. This is the unprecedented bridge type in the world. After it is built, it will not only have tourists on the scoop but also be talked about delightedly in the bridge engineering sector.

In landscape, Riyue Bridge is one bridge which is quite beautiful and incorporates perfectly the local environment. In mechanics structure, the transverse rigidity of the deck and the vertical rigidity of the arch both are fully utilized so that a quite sylphlike structure could be available but it can resist the strong earthquake in Tianjin region.

This bridge is not only a traffic passage between tow banks but also a tourist attraction itself. If it is narrow, it will have tourist feel inconvenient activities and the bridge itself is lack of grand vigor. Therefore, sidewalks must be with certain width to let tourists feel more comfortable and sufficient room on the bridge so as to have more room for tourists to stop to enjoy the water environment.

3 STRUCTURAL CHARACTERISTICS OF RIYUE ARCH

The Dagu Bridge with novel design concept and unique bridge type. It is 154m long totally, the deck is 30~59m wide. The driveway is 24m wide. The span is arranged in 24+106+24m. Its structure is the through tied arch.



Figure 9 : Dragon dancing while the sun and the moon shining



Figure 10 : Enjoy the water environment

Riyue arch consists of two asymmetric steel box arches. The crown of the big arch is 39m high with arc of 140m long. It inclines outward at 18 degrees and faces the east, symbolizing the sun. The crown of the small arch is 19m high with arc of 116m long. It inclines outward at 24 degrees and faces the west, symbolizing the moon. The two arches form one integrated mass but echo each other.

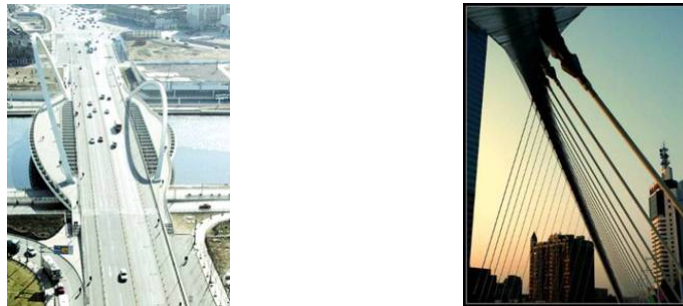


Figure 11 : Birdge details

The two arches are tied by 88 tie cables on both sides of the arches. These cables face the semi-circle view platform extended outward from the bridge. The cable system allows cables to bear the weight which should be carried by the bridge so that pier is not required to be built in the middle of the river. And a wonderful landscape of overflying the Haihe River appears.

Steel structural system is applied for construction of Dagu Bridge. It is technically skilled in terms of processing, manufacturing and installation. The main girder is the orthotropic steel plate box one with low weight and high plane rigidity. It is the structure applicable to the strong earthquake region. With assistance of stable 3D cables, action of the steel box arch rib is definite and the structure can be manufactured more slender.

To the innovative structural form, the construction contractor applies the construction scheme of economic and applicable integrated scaffold, which lets the complete construction technology of installation of steel box arch, precision control, outline control, closure, survey and

positioning can directly and simple. Concerning the key point of connection between the suspension cables and the arch rib top, test on fatigue performance of the top connection structure of the suspension cable is executed. Scientific and valuable redult data are acquired, and reliability of the connection structure is guaranteed accordingly.



Figure 12 : Under construction

4 BIRTH STORY OF DAGU BRIDGE

In 2003, the scheme review for Riyue Bridge recommended by T. Y. LIN International China was passed by the expert panel;

Detailed design and optimized design of the structure were executed. Formal scheme was finalized through review and technical design was fulfilled;

Detailed design of steel structure was fulfilled. Construction commenced on July 6, 2004 and completed to open in May, 2005.

Outstanding design, beautiful shape and advanced technology, Dagu Bridge gain high reputation in the world. *For the outstanding achievement in bridge engineering that, through vision and innovation, provides an icon to the community for which it was designed Dagu Bridge, Tianjin, China.* This is the appraisal for Dagu Bridge by Eugene C. Figg. Jr. Prize.

Dagu Bridge (Riyue Bridge) is the top one in the world with respect to its technology and beautiful shape or in art. It is the new bridge type applied in the world first. Now this bridge is one of important tourism attractors for people to visit the Haihe River in Tianjin. It has become the new namecard of Tianjin City.

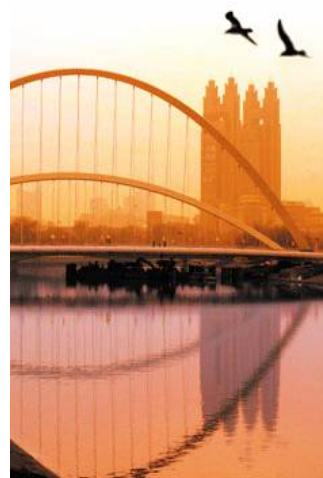
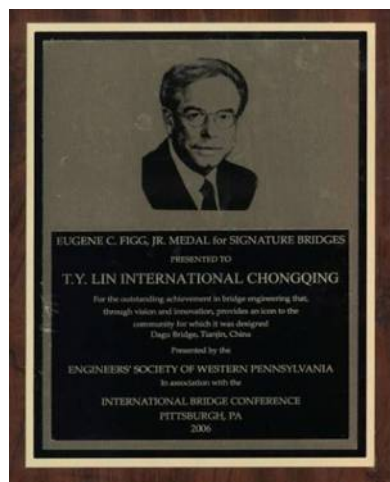


Figure 13 : Eugene C. Figg. Jr. Prize

Golden dragon is dancing while either Sun or Moon is shining. Dagu Bridge beautifies not only the Haihe River but also the whole Tianjin City.



Figure 14 : View of completed Dagu Bridge