The Chenglang Bridge-A New Landmark of Ningbo City

Located at Taoyuan Street in the central city of Ningbo, with a main span of 185m, Chenglang Bridge crosses the Fenghua River with only one span. Designed as a half-through tied-arch bridge without wind bracing, it looks beautiful, stretched and elegant. The shape of the whole bridge originated from the idea of the rising sun. Displaying full imagination and innovation, it is another city sculpture and landmark of the modern city Ningbo. The main design features of the bridge are as follows.

1. Displaying full play to imagination, a distinctive urban highlight was created according to the geographical location and surrounding environment of the bridge.

The most important difference of Chenglang Bridge from other bridges lies in the flourishing and prosperous vision carried by it. Ningbo is located in the due east of the China mainland, where the sun rises. The rising sun is vigorous and symbolizes the flourish and prosperity of the city. The designers took the rising sun as the design element and applied it to the overall shape of the bridge. The flat arch with a rise-span ratio of 1/8 perfectly integrates with the surrounding environment, coordinates with the shapes of the upstream and downstream bridges, without bringing confusion and burden to the existing river skyline, and endows the bridge with a distinctive stretching shape and elegance. Pursuing pure color and simple form and abandoning all restraints and excess accessories, including the conventional cross-wind bracing, we only retained the most indispensable architectural lines in our minimalist style. Behind the flying imagination, it is a powerful and advanced structural design concept, technological ability, and an incredible simple form created by the advanced and feasible technical solution.

2. Innovation was always kept as one of the design principles, and was fully implemented in the whole design process.

According to the shape and landscape requirements of the bridge, a new half-through arch bridge structure system on soft soil ground was proposed in this design. The three-span tied-arch bridge type is usually adopted to construct a half-through arch bridge on soft soil ground. The tie bars anchored at both ends of the side spans are usually used to resist horizontal thrust of the main arch. At Chenglang bridge, the conditions for a side-span are unavailable. So a new type of half-through tied-arch bridge structure was proposed in the design creatively. In the structure system, the tie bar is directly anchored to the corresponding girder position on the main arch rib and the side span flying-bird-type arch ribs commonly used is canceled. The main girder is a floating system, and the horizontal force is offset by the tie bar anchored in the arch rib, thus having ingeniously solved the issue of horizontal force for the arch bridge on soft soil ground, guaranteed the outstanding visual effect of the main arch, and reduced the scale of the main bridge and cut the construction cost, and offering a new choice of structural form for bridge construction in the soft soil area.

Based on the shape and overall layout of the bridge, the main girder is designed with the combination of box girder and lattice girder, which is a new attempt in the form of main girder construction. The main girder of the bridge is 185m long, but the suspenders can only support the 120 m in the middle of the main girder, and no suspension support is designed for the 32.5m main girder on both sides, which need to be supported on the pier column at both ends. Because of this, the main girder is designed innovatively with the combination of box girder and lattice girder. The main girder is designed as the lattice girder form in the suspender area to bear the stress in the transverse direction of the bridge through the cross beam and as the box section form in the non-suspender area to bear the stress in the longitudinal direction of the bridge. The combination of the longitudinal and transverse girder system and the box section structure system in the same structure, as a beneficial attempt for the design of similar bridge structures, leads to more reasonable load-bearing of the main girder and a lower construction cost.

3. Chenglang Bridge, which has become a new scenery on the Fenghua River and a new business card for Ningbo, is another local landmark bridge.

The construction of Chenglang Bridge fully took account of the surrounding environment, urban development, cultural landscape and many other construction conditions. It gave full play to imagination and innovation, and aimed to build a bridge in the public interest characterized by harmony with the environment, adoption of advanced technology, and beautiful and exquisite appearance, thereby making contribution to the urban development and construction of Ningbo. Chenglang Bridge has drawn attention from the general public and local news media since the start of its construction. The completed bridge not only provides convenient traffic between the two banks, but has also become a leisure walking and sightseeing space for the residents nearby together with the surrounding green belt. In the constantly changing colorful lights at night, the bridge, looking like a rainbow across the water surface also, symbolizes the colorful life of the people in Ningbo. The completed bridge has become another city sculpture and landmark of the modern city Ningbo.
Details of The Chenglang Bridge

Located at Taoyuan Street in the central city of Ningbo, Chenglang Bridge crosses the Fenghua River with only one span. Designed as a half-through tied-arch bridge without wind bracing. Chenglang Bridge, with a total length of 448m and a standard width of 33.5m has 6 lanes in two ways plus the non-motorized vehicle lanes and sidewalks. The main bridge is 185m long. As the main load-bearing member and with a rise-span ratio of 1/8, the main arch is designed as two arch ribs in the transverse direction of the bridge, and has an inward inclination of 10°. There is no wind bracing between the two main arches. Enclosed rectangle steel box type arch ribs are adopted for the main arch, and one enclosed steel box is changed into two near the 1/4 span of the main arch. The two steel box arch ribs are supported and connected with a steel truss. Such a section layout not only meets the load bearing requirements, but also avoids leaving the impression of thickness and heaviness by the high and wide steel boxes, thus creating a good visual effect. (see in Figure 1)

The main bridge is designed with the 2m high steel girders. The suspenders of the main bridge have a space of 6 m between each other in the longitudinal direction of the bridge and incline along with the arch ribs in the transverse direction of the bridge. The suspenders are in the same plane as the arch axis. The tie bars of the main bridge act as the main members to resist horizontal force of the bridge, and are anchored in groups on the anchor groove at the top of the arch ribs of the upper and lower limbs. Bored cast-in-place pile foundation is designed as the main bridge foundation.

The main design features of the bridge are as follows.

1. Displaying full play to imagination, a distinctive urban highlight was created according to the geographical location and surrounding environment of the bridge.

Creation of Chenglang Bridge was started with the selection of bridge type. The bridge is located in the central city of Ningbo, spanning the Fenghua River that is about 150 m wide, within the reasonable span range for an arch bridge. The bridge designers of different times have meticulously designed and built the arch bridges of different styles and materials here, which are harmonious with each other, telling the story of history, and form a unique water architecture texture (see in Figure 2). It is also a good opportunity for us to bring the feelings and concepts as well as aesthetics and technology of our time to the river and city with a brand new arch bridge.
From the perspective of urban spatial layout, Chenglang Bridge connects Ningbo CBD expansion base on the west bank of the river and the high-grade residential areas on the east bank of the river. The bridge is situated among high-rise buildings, creating a skyline in an obvious concave shape. In the scenario of continuous arches, the whole space is filled, producing a sense of fullness and swelling (see in Figure 3). In the scenario of the cable and tower structure, the bridge tower is submerged among high-rise buildings (see in Figure 4). The single-span arch bridge form enables the skyline to present a good sense of sequence and rhythm, in the process from high to low and to high (see in Figure 5).

The most important difference of Chenglang Bridge from other bridges lies in the flourishing and prosperous vision carried by it. Ningbo is located in the due east of the China mainland, where the sun rises. The rising sun is vigorous and symbolizes the flourish and prosperity of the city. The designers took the rising sun as the design element and applied it to the overall shape of the bridge (see in Figure 6). The flat arch with a rise-span ratio of 1/8 perfectly integrates with the surrounding environment, coordinates with the shapes of the upstream and downstream bridges, without bringing confusion and burden to the existing river skyline, and endows the bridge with a distinctive stretching shape and elegance. Pursuing pure color and simple form and abandoning all restraints and excess accessories, including the conventional cross-wind bracing, we only retained the most indispensable architectural lines in our minimalist style. Behind the flying imagination, it is a powerful and advanced structural design concept, technological ability, and an incredible simple form created by the advanced and feasible technical solution (see in Figure 7).
2. Innovation was always kept as one of the design principles, and was fully implemented in the whole design process.

According to the shape and landscape requirements of the bridge, a new half-through arch bridge structure system on soft soil ground was proposed in this design. The three-span tied-arch bridge type is usually adopted to construct a half-through arch bridge on soft soil ground. For soft soil ground, the structure with only pile foundation or ground to resist horizontal thrust generated by the arch bridge will be highly costly. The tie bars anchored at both ends of the side spans are usually used to resist horizontal thrust of the main arch (see in Figure 8). At Chenglang bridge there is a level crossing on one side of the bridge, and the deck is only about 5m above the ground. With the side-span arch ribs, the bridge will suffer from a flat alignment, unreasonable stress, and unsatisfactory overall visual effect. Moreover, there is an existing road near the foot of the main arch on the other side of the bridge, so the conditions for a side-span are unavailable. A new type of half-through tied-arch bridge structure was proposed in the design creatively, based on the above-mentioned construction conditions. In the structure system, the tie bar is directly anchored to the corresponding girder position on the main arch rib and the side span flying-bird-type arch ribs commonly used is canceled (see in Figure 9). The main girder is a floating system, and the horizontal force is offset by the tie bar anchored in the arch rib, thus having ingeniously solved the issue of horizontal force for the arch bridge on soft soil ground, guaranteed the outstanding visual effect of the main arch, and reduced the scale of the main bridge and cut the construction cost, and offering a new choice of structural form for bridge construction in the soft soil area.

Based on the shape and overall layout of the bridge, the main girder is designed with the combination of box girder and lattice girder, which is a new attempt in the form of main girder construction. The main girder of the bridge is 185m long, but the rise-span ratio of the main arch is only 1/8 according to the requirements of the bridge shape, and the main arch is relatively flat. Therefore, the suspenders can only support the 120 m in the middle of the main girder, and no suspender support is designed for the 32.5m main girder on both sides, which need to be supported on the pier column at both ends, resulting in the transverse load-bearing requirement of the main girder in the transverse direction of the bridge in the suspender area and the load-bearing requirement in the longitudinal direction of the bridge in the non-suspending area. To this end, the main girder is designed innovatively with the combination of box girder and lattice girder (see in Figure 10). The main girder is designed as the lattice girder form.
in the suspender area to bear the stress in the transverse direction of the bridge through the cross beam and as the box section form in the non-suspending area to bear the stress in the longitudinal direction of the bridge. The combination of the longitudinal and transverse girder system and the box section structure system in the same structure, as a beneficial attempt for the design of similar bridge structures, leads to more reasonable load-bearing of the main girder and a lower construction cost.

3. Chenglang Bridge, which has become a new scenery on the Fenghua River and a new business card for Ningbo, is another local landmark bridge.

The Fenghua River runs through Ningbo City. The bridges crossing the Fenghua River, which were built earlier, feature conventional shapes, and lack of imagination and creativity (see in Figure 2), looking disharmonious with the ever-changing urban development and construction. The construction of Chenglang Bridge fully took account of the surrounding environment, urban development, cultural landscape and many other construction conditions, it gave full play to imagination and innovation, and aimed to build a bridge in the public interest characterized by harmony with the environment, adoption of advanced technology, and beautiful and exquisite appearance (see in Figure 11), thereby making contribution to the urban development and construction of Ningbo. Chenglang Bridge has drawn attention from the general public and local news media since the start of its construction (see in Figure 12). The completed bridge not only provides convenient traffic between the two banks, but has also become a leisure, walking and sightseeing space for the residents nearby together with the surrounding green belt (see in Figure 13). In the constantly changing colorful lights at night, the bridge, looking like a rainbow across the water surface, symbolizes the colorful life of the people in Ningbo. The completed bridge has become another city sculpture and landmark of the modern city Ningbo.