Design and Construction

Overview of the Construction Scheme for the Jiasong Highway Bridge over the Huangpu River

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Abstract: The Jiasong Highway Bridge over the Huangpu River is located in Songjiang District, Shanghai. It is planned as a secondary highway with six lanes in both directions and non-motorized lanes on both sides. The main bridge design adopts a (130 + 336 + 130)-m self-anchored suspension bridge. In this paper, the bridge construction plan is systematically analyzed and compared with alternative designs, considering aspects such as the overall scheme, main bridge design, and main bridge construction methods. These evaluations are based on construction conditions, such as hydrology, geology, navigation, and the environment. The aim of this study is to provide a reference for the design and construction of similar bridges in the future.

Keywords: Jiasong Highway; self-anchored suspension bridge; construction scheme

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1 Project Overview

The Jiasong Highway Bridge over the Huangpu River is located in the Songjiang District, Shanghai, and is the planned Songpu Fourth Bridge, which will extend southward from the Jiasong Highway and cross the Huangpu River. The planned road classification for the new cross-river bridge of the Jiasong Highway project is a secondary highway [1]. It starts at Jinping Road in the north and ends at Songjin Highway in the south, with a total length of 1,825 m and a red line width of 40 m/50 m, as shown in Figure 1.

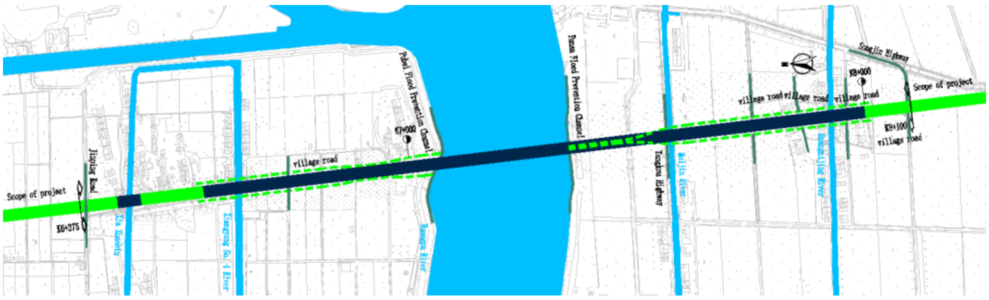

Figure 1 Location map of the Jiasong River-Crossing Bridge

2 Overall Scheme

2.1 Bridge Alignment Comparison

The selection of the bridge alignment should be comprehensively evaluated based on economic efficiency, implementability, and site conditions. This project compared two alternative alignments (Figure 2). The planned alignment follows a slightly southeast straight line from TaMin Road, crossing the Huangpu River and connecting to Yexin Highway. It is approximately 4.5 km in straight-line distance from the Chenta Road Bridge over Hengliaojing upstream and about 2.9 km from the Songpu Third Bridge on Songwei Highway. The spatial distribution of these three

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bridges is considered appropriate, and the planned alignment avoids the sharp right-angle bend of the Huangpu River. Considering advantages such as minimal relocation requirements, excellent road alignment, and relatively low implementation difficulty, this alignment was ultimately selected as the planned scheme.

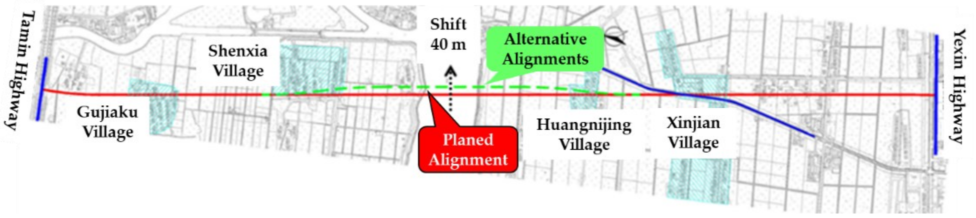


Figure 2 Relationship between planned alignment and alternative alignments

2.2 Comparison of Pedestrian and Non-Motorized Vehicle Crossing Schemes

The project reviewed existing pedestrian and non-motorized vehicle crossing solutions at nearby river-crossing facilities. The Chenta Road Bridge over Hengliaojing, Songpu Third Bridge, and G320 Songpu Bridge all incorporate dedicated passages for pedestrians and non-motorized vehicles. However, these existing crossings are primarily located on the eastern and western sides of Songjiang New City, leaving a significant gap in service coverage. Within the project area, pedestrians and non-motorized vehicles would need to detour to the Songpu Third Bridge on Songwei Highway to the east (2.9 km straight-line distance) or the Chenta Road Bridge over Hengliaojing to the west (4.5 km straight-line distance) (Figure 3), resulting in substantial inconvenience for cross-river travel.

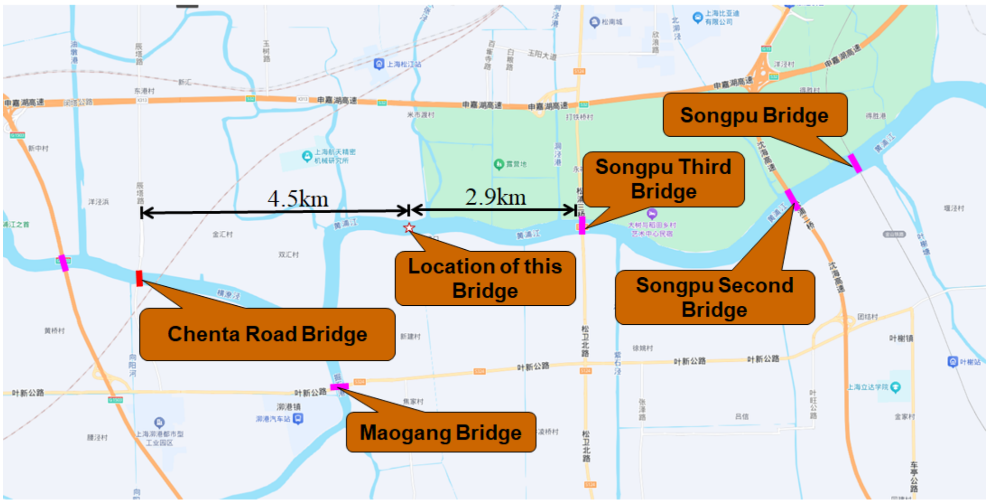


Figure 3 Schematic diagram of cross-river passageways in Songjiang District

In recent years, alongside adjustments to regional development strategies, the areas north of the river have focused on secondary and tertiary industries with higher economic value, while the regions south of the river have prioritized agriculture (particularly modern eco-agriculture) to preserve the original ecological environment. This developmental disparity has resulted in the overall progress of the southern regions lagging behind the northern areas, leading to a phenomenon of surplus labor migration from the south to the north. Consequently, the demand for pedestrian and non-motorized vehicle river crossings has been steadily increasing.

In the future, with the completion of large residential zones in southern Songjiang, the attractiveness of the northern areas—especially the southern new town—to the southern regions will further intensify, strengthening interregional connectivity. Given the considerable number of villages along and near the Jiasong Highway, pedestrian and non-motorized travel cannot be overlooked. It is essential to adequately accommodate the needs of pedestrian and non-motorized traffic in the Jiasong Highway river-crossing passage.

On the other hand, if a scheme without pedestrian and non-motorized vehicle access on the bridge is adopted, pedestrians would only be able to rely on conventional public transport for river crossing. This would necessitate the addition of cross-river bus routes and the installation of bus stops at both ends of the bridge. Following the urban "P+R" (Park and Ride) operational model, centralized parking areas for non-motorized vehicles should be established near bus stops to facilitate transfers. However, this scheme offers poor mobility, fails to provide point-to-point service, and would somewhat increase commuting costs for residents along the route. Given these series of issues associated with excluding pedestrian and non-motorized access on the bridge, the project currently considers incorporating dedicated passages for pedestrians and non-motorized vehicles on the bridge.

2.3 Overall Scheme

The Huangpu River-crossing bridge is designed with six vehicular lanes (bidirectional) + two non-motorized lanes on both sides, featuring a main bridge length of 596 m with a bidirectional 2.49% vertical grade. The approach bridges span a total length of 857.8 m. Below-deck auxiliary roads accommodate two mixed-use lanes (bidirectional) for combined motorized, non-motorized, and pedestrian traffic [2]. The general layout of the bridge is shown in Figure 4, while typical cross-sections of the main bridge and approach bridges are detailed in Figure 5 a) and Figure 5 b), respectively.

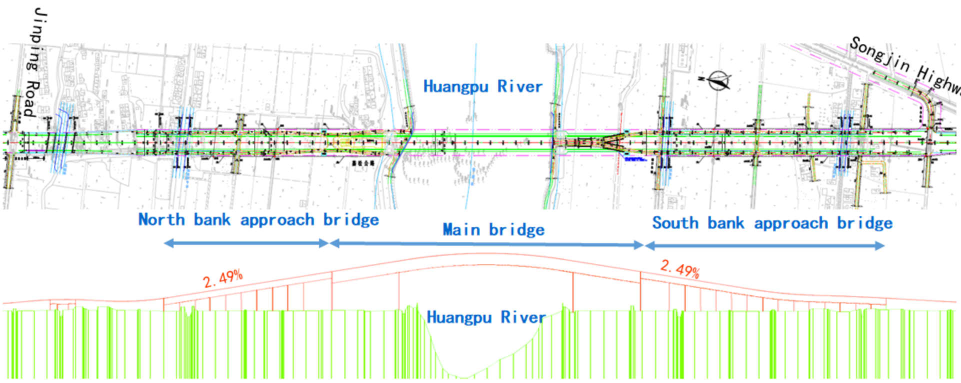
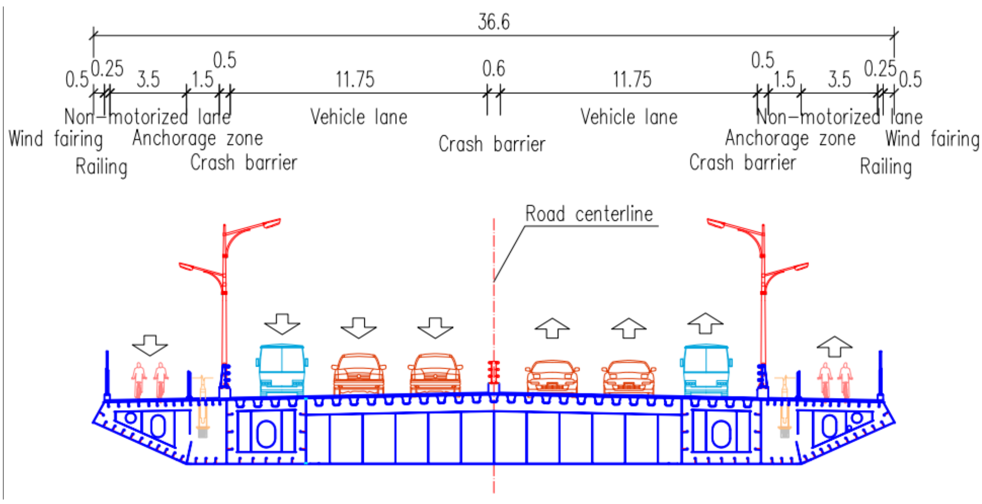


Figure 4 Overall layout scheme of the Jiasong River-crossing bridge



a) Cross-section of the main bridge

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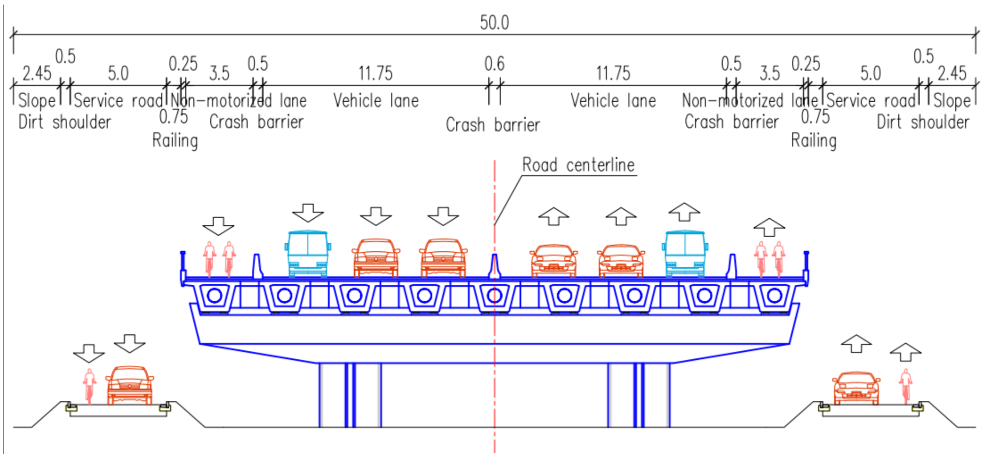


b) Cross-section of the approach bridge

Figure 5 Cross-section of the Jiasong River-Crossing Bridge

3 Design Scheme

3.1 Comparison and Selection of Bridge Type Schemes

In the scheme selection process, the following design criteria were strictly adhered to in accordance with the location characteristics and functional requirements of the proposed bridge:

(1) Planning coordination principle: Ensure that the overall design plan is consistent with the Shanghai Master Plan and the layout of the backbone road network and fully aligns with the project's functional positioning as an important transportation hub in the city.

(2) Adaptability principle: Strictly follow river management and navigation standards; scientifically establish bridges, culverts, and other water-related structures; and ensure river flood safety while meeting navigation requirements.

(3) Ecological friendliness principle: Optimize the layout design of roads and bridges, focus on enhancing landscape aesthetics, and minimize the impact on the ecological environment of secondary water source protection areas during construction and operation.

Conventional prestressed concrete continuous beam bridges, prestressed concrete continuous rigid frame bridges, and certain cable-stayed bridges are suitable for spans of less than 200 m. For a bridge with a main span of 336 m, if the aforementioned beam bridge design scheme is adopted, the main beam structure height would be relatively large, resulting in poor economic efficiency. For a main span of 336 m, the available bridge types are limited to self-anchored suspension bridges, cable-stayed bridges, and arch bridges.

3.1.1 Self-Anchored Suspension Bridge

Suspension bridges have been used worldwide since the late 19th century and underwent rapid development in the 1930s, with spans now reaching the kilometer-scale range. Self-anchored suspension bridges anchor the main cables directly to the main beam, thereby eliminating the need for massive anchorages [3].

Given the specific conditions of this bridge, when the river spans a single span, a (130+336+130)m self-anchored suspension bridge configuration can be adopted, with the bridge towers positioned outside the riverbanks on both sides and the main bridge arranged in longitudinal symmetry (Figure 6). The main beam has a steel box girder + composite deck slab structure, with a uniform main beam height, and the spacing between main beam transverse stiffeners is set at 4 m. The building height is relatively low, reducing the bridge length. The main bridge is equipped with two main cables, arranged in a parallel double-cable configuration, with a hanger spacing of 12 m.

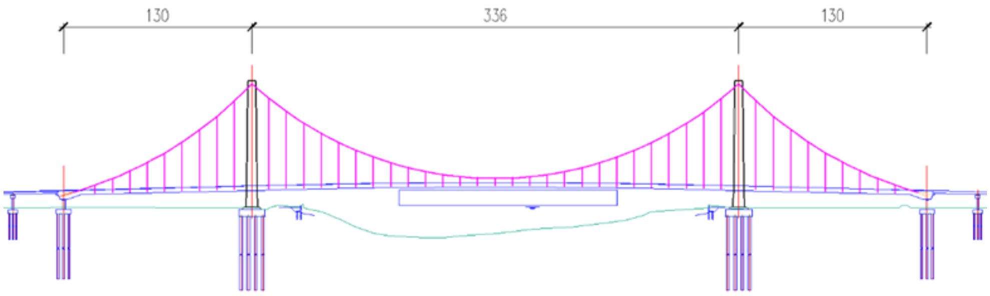


Figure 6 Self-anchored suspension bridge elevation layout diagram

Self-anchored suspension bridges do not require the construction of large-scale anchorages, resulting in an elegant appearance. However, since the main cable is directly anchored to the main beam, the main beam bears a large axial force. Therefore, the cross-section of the main beam and the amount of steel used in the main cable must be increased, resulting in a significant increase in cost. Additionally, since the main cables and hangers can only be installed after the main beam and bridge towers are completed, temporary scaffolding or other methods must be used to install the main beam, resulting in more complex construction and higher construction costs. However, the material used for main towers, foundations, and stay cables is more economical than that for cable-stayed bridges.

3.1.2 Cable-Stayed Bridge

Cable-stayed bridges have been in use since the 1970s and developed rapidly in the 1990s, with their spans now extending to extra-large spans. The economic span of cable-stayed bridges is 300 m or greater.

Given the specific conditions of this bridge, the navigation channel is essentially symmetrical, allowing for the adoption of a double-tower, double-cable-stayed bridge configuration with spans of (50+100+336+100+50) m, which falls within the economically viable span range for cable-stayed bridges (Figure 7). The main beam has a double-girder steel–concrete composite beam with three small longitudinal beams inside. The cable spacing on the beam is set at 8 m, and the maximum segment weight of the main beam is approximately 260 tons. The main beam has a uniform height of 3 m, resulting in a relatively low structural height, which can reduce the bridge length caused by vertical curves.

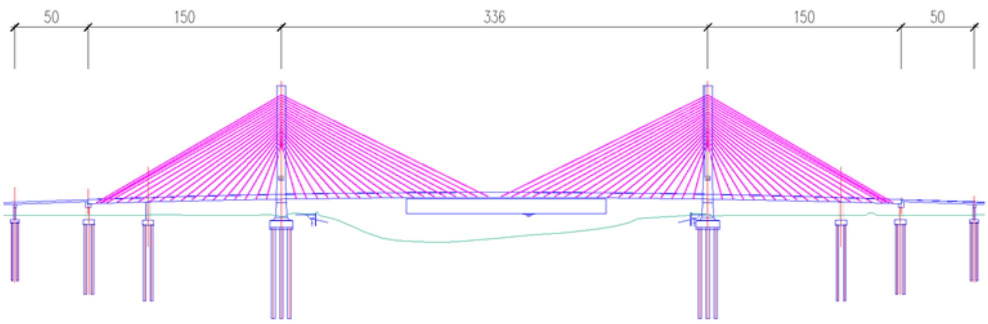


Figure 7 Cable-stayed bridge elevation layout diagram

3.1.3 Arch Bridge

Steel truss arch bridge is a type of bridge that has been widely adopted in recent years for long-span railway bridge applications. As design and construction techniques have matured and with the ability to accommodate diverse deck layout configurations while significantly reducing bridge height, the construction of these bridges is increasingly favored in environments where bridge aesthetics and structural height are critical considerations.

The main bridge features a 336-m span lower-chord steel truss arch bridge, with a span arrangement of (95+336+95) m (Figure 8). The main bridge deck structure consists of steel tie beams, steel cross beams, small steel longitudinal beams, and reinforced concrete deck slabs. The width of the tie beams is the same as that of the steel truss arches, with steel transverse beams spaced at 4.5 m intervals. The steel tie beams, steel transverse beams, and longitudinal beams form the bridge deck grid beam system. Powerful horizontal stay cables are arranged between the transverse beams at both ends of the main bridge to balance the horizontal thrust caused by the dead and live loads on the main span arch ribs. The hangers arranged along the bridge axis are straight hangers spaced at 9 m intervals.

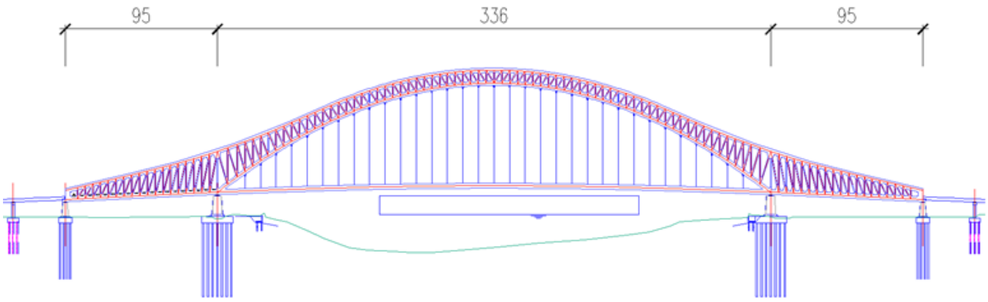


Figure 8 Arch bridge elevation layout diagram

The height of bridge structures is controlled by the crossbeam, which can significantly reduce the height of the structure compared with that of other bridge types, thereby shortening the length of the bridge.

The greatest problems with this type of bridge are that the construction process is complex, the construction difficulty is high, the construction costs are high, the shipping management during construction is complex, and the construction timeline is difficult to ensure.

3.1.4 Comprehensive Comparison

Table 1 Comparison of different bridge design schemes

Schemes	Self-anchored suspension bridge	Cable-stayed bridge	Arch bridge
Bridge span arrangement	（130+336+130）m	（50+150+336+150+50）m	（95+336+95）m
Technical challenges	Technologically mature and relatively easy to implement	Technologically mature and relatively easy to implement	High technical challenges
Construction methods and construction risks	The main beam is constructed by less support jacking or cable-stayed buckle cable, and the construction risk is small	Cantilever assembly construction, low construction risk	The use of fewer supports during construction poses a greater risk
Construction period	30 months	30 months	34 months
Construction speed	The main tower and main beam are constructed simultaneously, resulting in rapid construction	Assembly construction speed is relatively fast	The manufacturing speed of distributed components is relatively fast, but installation is relatively slow

Schemes	Self-anchored suspension bridge	Cable-stayed bridge	Arch bridge
Impact on navigation	The construction of the main beam with cable-stayed bracing has little impact on navigation	Temporary closure of navigable waters is required during the construction of the main beam, which will have a minimal impact on navigation	The construction of the main beam and arch ribs requires the erection of temporary piers, which will have a significant impact on navigation during the construction period
Driving comfort	High structural rigidity and good driving comfort.	High structural rigidity and good driving comfort.	High structural rigidity and good driving comfort.
Postconstruction maintenance	High costs.	High costs.	All-steel structure, difficult to maintain, and high cost.
Landscape	Gentle and elegant appearance.	Imposing, simple.	Elegant design, dynamic appearance.
Economic efficiency	Relatively good, slightly more expensive than cable-stayed bridges.	Good.	Slightly more expensive.

After a comprehensive evaluation, the cable-stayed bridge design offers significant economic advantages and a mature construction technology system, making it the most widely used among existing bridges across the Huangpu River. However, this bridge design has homogenization issues. The arch bridge design is constrained by factors such as many components, complex construction processes, and relatively low economic efficiency, and there is already a demonstration case of the LuPu Bridge in the region. Although the self-anchored suspension bridge scheme involves higher initial construction costs, its life-cycle cost (including 50-year cable replacement and maintenance) is generally comparable to that of cable-stayed bridges. Its unique spatial cable system creates distinctive visual identity and landscape recognition. Considering the need for efficient utilization of the scarce bridge sites along the Huangpu River, the final selection was a double-tower, double-cable surface self-anchored suspension bridge design. The main bridge has a span combination of (130+336+130) m (Figure 9), which not only meets navigation requirements but also creates a city landscape bridge with landmark characteristics [4].

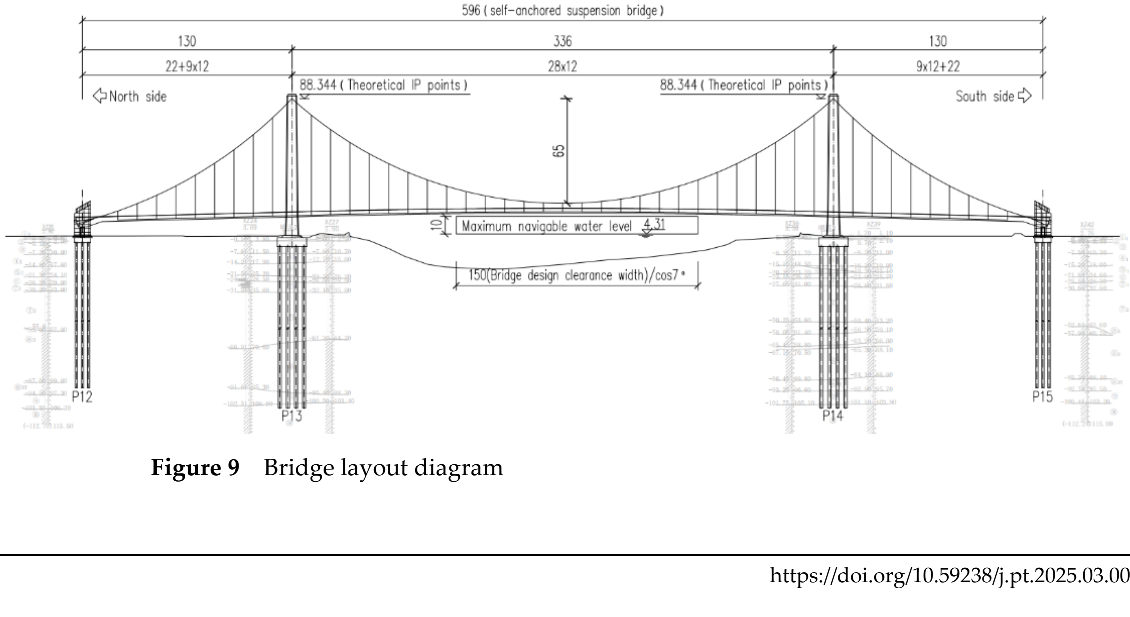


Figure 9 Bridge layout diagram

3.2 Comparison of key structural alternatives for the main bridge

3.2.1 Side-to-Main Span Ratio

The side-to-main span ratio has certain impacts on the structural vertical stiffness, abutment reactions, and steel cable consumption. Since self-anchored suspension bridges typically have relatively small spans, vertical stiffness is not the controlling condition in their design. Therefore, the side-to-main span ratio is generally maintained within the range of 1/2.1 to 1/2.7, which has minimal influence on the structural mechanical behavior. Table 2 presents the side-to-main span ratios of self-anchored suspension bridges recently constructed in China.

Table 2 Statistics on side-to-main span ratios of self-anchored suspension bridges

Bridge name	Span combination	Side-to-main span ratio
Taohuayu Bridge, Zhengzhou	160+406+160	1/2.57
Sanchaji Bridge, Changsha	70+132+328+132+70	1/2.48
Tianhe Bridge, Songyuan	40+100+266+100+40	1/2.66
Jianghan Sixth Bridge, Wuhan	48+57+110+252+110+57+48	1/2.29
Yangmingtan Bridge, Harbin	46+108+248+108+46	1/2.30
Luozhou Bridge, Fuzhou	80+168+168+80	1/2.10
Binhe Yellow River Bridge, Yinchuan	88+218+218+88	1/2.48
Xiaogan Second Bridge, Zhoushan	150+370+150	1/2.47

Based on previous engineering experience, the main bridge side span is 130 m, the middle span is 336 m, and the side-to-main span ratio is 1/2.58, which is within a reasonable range [5].

3.2.2 Anchor Span Arrangement

Considering the load-bearing characteristics of self-anchored suspension bridges, combined with the counterweights of the side pier, self-anchored suspension bridges generally have a five-span continuous structure or a three-span continuous structure. A five-span continuous structure involves extending the side span by one additional span (anchor span), which is then combined with counterweights to counteract the negative reaction forces from the side pier. This design is currently among the most commonly used solutions, as seen in the Sanchaji Xiangjiang Bridge in Changsha , Yangmingtan Bridge in Harbin, Tianhe Bridge in Songyuan, and Huangshui River Bridge in Xining. An anchor span is typically constructed using steel or concrete beams. Due to the influence of the local terrain and road conditions, there is a river and a rural road outside the side span of the south bank. Considering the arrangement of the approach bridge spans, if an anchor span is to be installed, a span of 55.0 m must be adopted.

Due to the large span, if concrete beams are used, the beam height will be too high, resulting in insufficient clearance under the bridge, a cramped space, and poor aesthetics. Additionally, concrete beams have high stiffness and are sensitive to uneven settlement in soft soil foundations. If steel main beams are used, the cost will be relatively high. Owing to the use of a longitudinal and transverse beam system, the connection between the anchor and side spans will be challenging.

Although anchor spans are beneficial for the overall structural integrity, they are relatively expensive. If a concrete anchor span is adopted, it exhibits sensitivity to settlement, making it unsuitable for soft soil foundations. Additionally, it results in oppressive under-bridge space and poor aesthetic appeal. Considering factors such as settlement sensitivity, economy, and aesthetics, this project does not include anchor spans and instead adopts a three-span structure.

3.2.3 Side Span Anchorage Segment Ballasting Scheme

Since the main cables of a self-anchored suspension bridge are anchored to the beam, significant uplift forces inevitably occur at the beam ends, resulting in negative reactions (uplift forces) at the side pier supports. To address this issue, three common solutions are typically employed (see Figure 10):

(1) Hybrid Beam Solution: The side spans utilize concrete beams (e.g., Pingsheng Bridge in Foshan, Fengxi Bridge in Zhuzhou). This approach is suitable when side spans lack suspenders. Its advantage lies in resolving negative reactions at side piers without increasing the main bridge deck area. However, note that construction methods differ between side spans (cast-in-place on bracket) and main spans (hoisting or incremental launching). Additionally, concrete side spans are settlement-sensitive and unsuitable for soft soil foundations.

(2) Corbel + Transition Span Ballasting: A corbel is provided at the end diaphragm of the side span tail, with simply supported concrete beams placed between the main and approach bridges to apply ballasting. The main cable anchorage employs steel structures with core-filled ballasting. A rotational expansion joint is installed between the transition span and the main bridge, while large-displacement expansion joints are relocated between the transition span and the approach bridge. This scheme was implemented in Nanchang Hongdu Bridge.

(3) Concrete Anchorage Block + Approach Bridge Ballasting: Main cables are anchored via concrete blocks (e.g., Luozhou Bridge in Fuzhou, Binhe Yellow River Bridge in Yinchuan), combined with simply supported concrete beams from the approach bridge for ballasting. This offers low cost and simple construction. During implementation, the incident angle at the cable anchorage zone should be minimized.

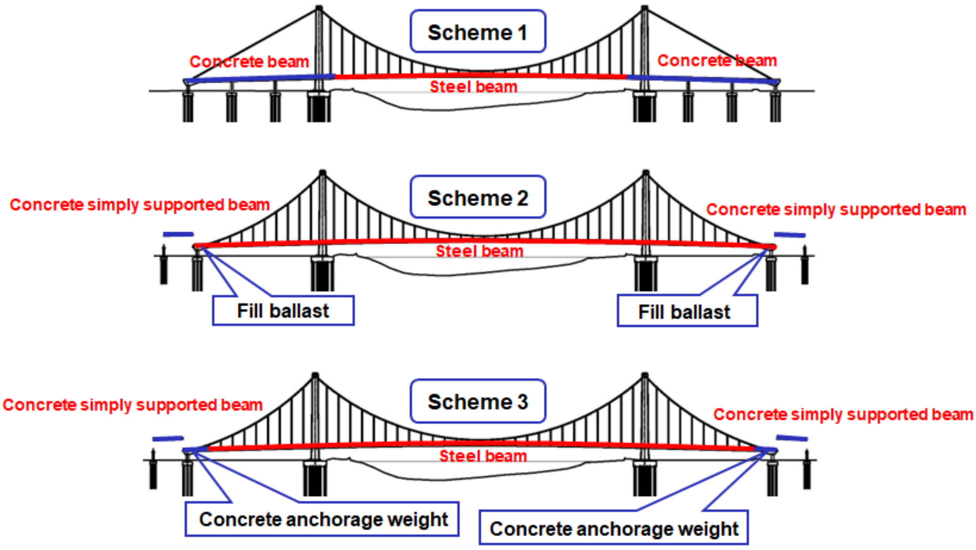


Figure 10 Schematic diagram of the three types of Ballasting methods

The bridge has a relatively long span. Although the incidence angle of the main cable is only 18°, the vertical component force remains considerable. Therefore, relying solely on the counterweight concrete poured within the anchorage section of the end crossbeam in the side span is insufficient, and additional counterweight from the approach bridge is required in the anchorage zone. To address the main cable anchorage issue, a combined counterweigh method is planned for the approach bridge and the anchorage segment of the transverse beam at the end of the side span, considering economic factors and other aspects [6-7].

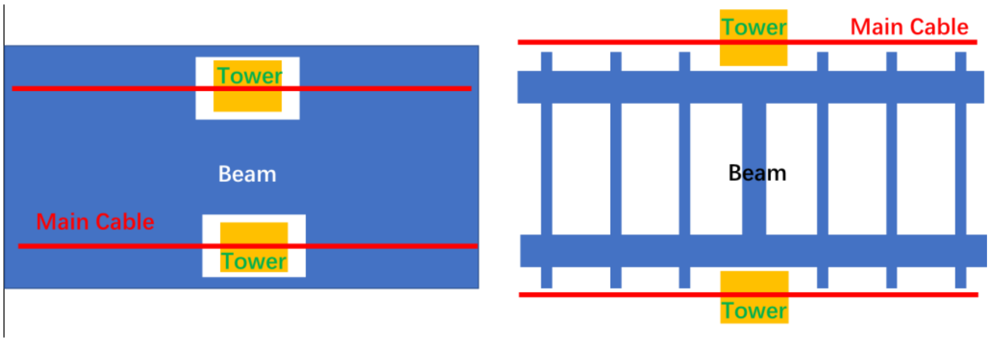
3.2.4 Main Bridge Cables

The cable planes of self-anchored suspension bridges can be categorized into single cable planes, parallel double cable planes, and spatial double cable planes. The single cable plane configuration offers a clear and straightforward appearance from a driving perspective, but it experiences significant transverse forces and has relatively weak torsional stiffness in the main beam, necessitating an increase in beam height to compensate for these deficiencies. In contrast, the double cable plane configuration provides better transverse load resistance and greater torsional stiffness in the main beam, allowing for a relatively lower beam height. Among these, the spatial double cable plane configuration can enhance the overall aesthetic appeal of the bridge, but it involves difficulties in fabrication and processing, challenges in on-site construction, and increased material usage. After considering both options, the parallel double cable plane structural system was ultimately adopted.

3.2.5 Tower-Beam Relationship

The load transfer mechanism of a self-anchored suspension bridge is as follows: loads act on the main beam and are transmitted to the main cable via the suspenders. The vertical component of the main cable force is resisted by the main tower, while the horizontal component is borne by the main beam. If the lines of action of the cable, tower, and main beam lie in the same plane, vertical loads will not induce additional forces.

When the main tower is vertical and the cable plane is aligned with the centroidal axis of the beam, the following two typical positional relationships between the tower and the beam are commonly observed in self-anchored suspension bridges, as illustrated in Figure 11.



a) Tower beam axis coplanar b) Tower beam axes are not coplanar

Figure 11 Plan layout of different tower beam relationships

(1) The tower and beam axes are coplanar

In this design scheme, the cables, towers, and beams are coplanar, as mentioned earlier, which does not impose additional forces on the structure, making it the best option in terms of load-bearing performance. However, considering the construction process, the middle and upper tower columns can be poured only after the main beams are installed, resulting in a longer construction period. Both the Nanchang Hongdu Bridge and the Fuzhou Luozhou Bridge adopted this scheme.

(2) The tower and beam axes are non-coplanar

In this design scheme, the main cable is coplanar with the tower axis, but there is an eccentricity between the main cable and the main beam axis. This scheme requires expanding the anchorage zone of the main cable and using a sufficiently long transition segment to transfer the forces from the main cable to the main beam axis. The advantage of this design is that the main beam and main tower can be constructed simultaneously, significantly reducing the construction period. This scheme has been adopted for the Harbin Yangmingtan Bridge, Wuhan Jianghan Sixth Bridge, Yinchuan Binhe Yellow River Bridge, and Zhoushan Xiaogan Second Bridge.

Considering the simultaneous construction of the main beam and the main tower, a non-coplanar scheme between the tower and the beam is adopted.

3.2.6 Constraint System

Common vertical restraint systems for the main beam include the fully floating system and the semi-floating system. The fully floating system does not employ vertical bearings at the junction between the tower and the beam and can be further divided into configurations with or without a stay (referred to as " hanger 0"). The semi-floating system utilizes vertical bearings at the tower-beam connection. Owing to the specific structural characteristics of the bridge's main tower, which preclude the installation of a hanger 0, only the fully floating system (without hanger 0) and the semi-floating system (with bearings) were analyzed and compared.

The calculation results (see Table 3) show that both systems have a certain, though limited, influence on live load deflection. The envelope diagrams of live load moments show minimal differences across most sections of the bridge, but a more significant impact on the local moments in the main beam near the bearings. Specifically, the semi-floating system results in considerably larger moments at the bearing locations of the main beam. Global stability analysis reveals that the first-order buckling mode for both systems involve instability of the main tower. The stability factor is 15.3 for the semi-floating system and 13.2 for the fully floating system. The difference is marginal, and neither value governs the design. Regarding aerodynamic performance, estimated critical flutter speeds for both schemes meet the required flutter check speed [8]. From a seismic perspective, the semi-floating system leads to more uniform force distribution and smaller internal forces in the two tower columns. Although the forces on the side piers are somewhat larger, they remain within an acceptable range [9].

Considering the results of static calculations, wind resistance performance, and seismic performance, the installation of vertical bearings can improve the wind resistance performance of the stiffened girder and slightly improve its seismic performance. Therefore, a semi-floating system was ultimately adopted, with vertical bearings installed at the junction of the tower and beam.

Table 3 Comparison of the main calculation results for the two constraint systems

Category		Fully floating system	Semi-floating system
Static calculation	Maximum bending moment of main beam under live load（kN·m）	86,736.56	88,098.42
	Minimum bending moment of main beam under live load（kN·m）	−70,494.28	−81,180.61
	Maximum deflection of main beam under live load（m）	0.292274	0.205909
	Maximum deflection value of the main beam under live load（m）	−0.441043	−0.350903
Global stability	First-order buckling mode	Buckling of main tower	Buckling of main tower
	First-order stability coefficient	15.3	13.2
Wind resistance (flutter critical wind speed m/s)	Wind attack angle +3°	69.5	73.9
	Wind attack angle 0°	103.8	110.4
	Wind attack angle −3°	>112.6	>119.7

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Category		Fully floating system	Semi-floating system
Seismic performance	First-order vibration mode and period	Main beam longitudinal drift + main beam vertical bend (T = 4.24 s)	Main beam longitudinal drift + main beam vertical bend (T = 4.09 s)
	Axial force at tower column base under transverse earthquake action (kN)	43,498.04	38,189.16
	Bending moment at tower column base under transverse earthquake action (kN·m)	595,513.75	586,087.41
	Axial force at tower column base under longitudinal earthquake action (kN)	38,929.23	32,791.05
	Bending moment at tower column base under longitudinal earthquake action (kN·m)	546,399.54	562,014.32
	Lateral displacement of main beams under earthquake action (m)	0.13	0.13
	Longitudinal displacement of main beams under earthquake action (m)	0.62	0.58

Considering the results of static calculations, wind resistance performance, and seismic performance, the installation of vertical bearings can improve the wind resistance performance of the stiffened girder and slightly improve its seismic performance. Therefore, a semi-floating system was ultimately adopted, with vertical bearings installed at the junction of the tower and beam.

4 Construction Scheme

Based on the characteristics of this bridge, two construction schemes can be adopted for the main beam: (1) Integral incremental launching scheme; (2) Incremental launching + cable-stayed temporary bracing scheme [10-12]. A comparison of different construction schemes is shown in Table 4.

Table 4 Comparison of the main bridge construction schemes

Scheme	Integral incremental launching	Incremental launching + cable-stayed temporary bracing
Scheme description	A temporary dock is constructed. Small beam segments are transported by barge to the dock, then slid to the launching platform for connection and incremental launching. The main beam is launched from one bank to the opposite bank.	The side spans and part of the main span are constructed using incremental launching, while the remaining main span segments are installed using the cable-stayed method.
Major temporary measures	One lifting dock, one temporary dock, beam transport access road, lifting platform, temporary piers, Nicola's beam transport vehicles.	Two temporary docks, temporary piers, launching platform and equipment, temporary steel towers, temporary stay cables and anchoring measures, deck cranes or floating cranes.

Scheme	Integral incremental launching	Incremental launching + cable-stayed temporary bracing
Construction period	Relatively long	Relatively short
Construction difficulty	Mature incremental launching technology; segmented approach reduces requirements for transport and lifting equipment. Only one on-site welding location with favorable conditions, no long-distance movement of welding equipment, ensuring welding quality.	This scheme involves system transformation, requiring high precision in construction and control, resulting in relatively higher construction difficulty.
Navigation impact	Long-term occupation of waterway	Short-term navigation closure during lifting
Impact on navigation	The launched beam is a continuous structure with high stiffness and strong spanning capacity. Large spacing between temporary piers requires setting temporary navigation openings at temporary piers and mid-span during construction. Fewer navigation closures, but narrower navigation width during construction. Long-term presence of mid-span temporary piers significantly impacts navigation.	Temporary piers are only set near the bank. Deck cranes can be used to install beam segments, with only temporary navigation closures during lifting. More frequent navigation closures, but wider navigation width during construction, resulting in lesser impact on waterway.
Economic efficiency	The two schemes are generally comparable in economic efficiency.	

After comprehensive consideration of factors such as feasibility, impact on navigation, economic efficiency, construction maturity, and technical difficulty, the scheme combining incremental launching for side spans and cable-stayed temporary bracing for the main span (Figure 12) has been adopted.

Through comparative analysis, the temporary stay cables are anchored in a "permanent-temporary integrated" manner at the reinforced window lattice cross-brace nodes (Figure 13). This approach not only meets temporary construction requirements but also reserves conditions for future main cable replacement.

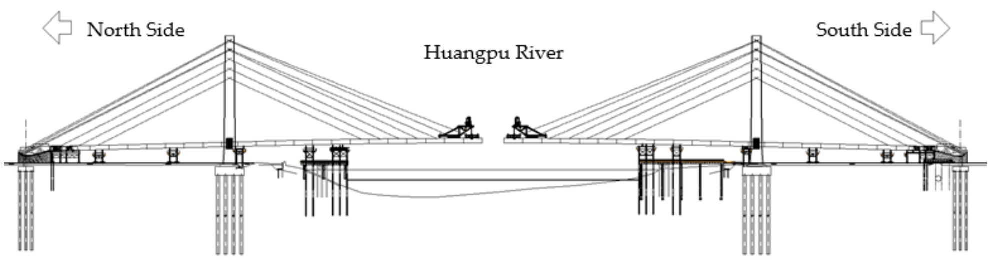

Figure 12 Schematic diagram of the construction scheme (incremental launching + cable-stayed temporary bracing)

 https://doi.org/10.59238/j.pt.2025.03.006

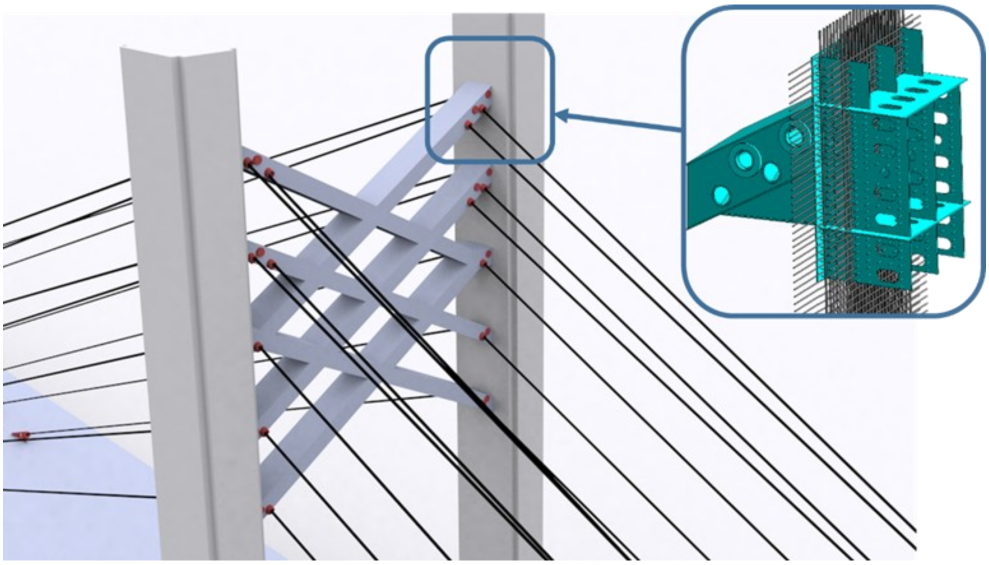

Figure 13 Three-dimensional diagram of a reinforced window lattice cross-brace node (temporary cable anchor node)

5 Conclusions

Based on hydrological, geological, navigational, and environmental conditions, the main construction schemes for the Jiasong Highway Bridge over the Huangpu River were thoroughly evaluated and compared. The main conclusions are as follows:

(1) The planned bridge site demonstrates significant advantages in terms of relocation volume, road alignment, implementation difficulty, and economic efficiency.

(2) Research indicates that accommodating pedestrians and non-motorized vehicles on the bridge is both necessary and urgent to meet local demands, as it will significantly improve cross-river travel options for pedestrians.

(3) After comparing bridge-type schemes from perspectives of aesthetics, cost, and construction feasibility, a self-anchored suspension bridge was ultimately selected.

(4) For the self-anchored suspension bridge design, key factors including side-to-main span ratio, anchor span arrangement, side span counterweight methods, main cable configuration, tower-girder relationship, and restraint systems were analyzed to determine the most rational layout.

(5) Considering on-site conditions, two construction techniques for the self-anchored suspension bridge were thoroughly compared. The scheme employing incremental launching for side spans combined with cable-stayed temporary bracing for the main span was ultimately selected due to its lesser impact on navigation.

Conflict of Interest: The author disclosed no relevant relationships.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author, Cao, upon reasonable request.

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