Scheme Comparison of Super-Large Span Bridge under the Condition of Limited Building Height

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Summary

Rongjiang super-large bridge is a part of the highway from Chaozhou to Huizhou in Guangdong province which is near to Chaoshan civil airport crossing Rongjiang River. In order to ensure the normal navigation under the bridge and meet the requirements of Airfield Height Control, both the span and the height of the bridge are limited, thus the main span should not be less than 380m while the bridge heights of the pier on the Chaozhou and the other side should respectively not be more than 96.65m and 109m .Due to the double restrictions of span and bridge height, three schemes are considered which include the scheme of steel-concrete composite box girder low-pylon cable-stayed bridge , self-anchored suspension bridge and prestressed steel truss-concrete composite through continuous rigid frame bridge which is proposed in this paper. Aiming at the prestressed steel truss-concrete composite through continuous rigid frame bridge, the design ideas are described, the general layout and the detailed construction are discussed and the mechanics property analysis in period of construction and service are also made to demonstrate the feasibility and reasonability of this scheme under given conditions .

Keywords: Navigation clearance limitation; Building height limitation; Scheme comparison; Prestressed steel truss-concrete composite through continuous rigid frame bridge; Design ideas; Construction feature; Mechanics property analysis.

1. Main Technical Standard and Restrictions of Building Height

As a part of the highway from Chaozhou to Huizhou in Guangdong province, Rongjiang super-large bridge locates at Rongjiang river where is near to Chaoshan civil airport. Chaohui highway Rongjiang Bridge is designed with the load standard of highway level-I, a bridge deck width of 33.5m.

The navigation level of Rongjiang river is level Ⅲwith a navigation of 1000 tons, therefore, to ensure the normal navigation under the bridge the restrictions of the bridge are regulated accordingly with a span of 380m. Besides, Rongjiang bridge is only about 5km far away from the Chaoshan airport, combined with the airport controlling height the bridge heights of the pier on the Chaozhou and the other side should respectively not be more than 96.65m and 109m.

2. Design of Bridge Style

Aiming at the environment and engineering characteristics, functions and landscape of Rongjiang Bridge, three schemes of the main bridge are proposed including the scheme of new half-through prestressed steel truss-concrete composite continuous rigid frame bridge, the scheme of steel-concrete composite box girder low-pylon `cable-stayed bridge and self-anchored suspension bridge.

The scheme of low-pylon cable-stayed bridge is proposed with a main span of 380m and a navigational clearance of 38m. Due to the restrictions of the local airport, the height of the pylon including lightning rod should not be more than 96.56m with the upper pylon of 45m. Considering all these factors, the bridge under the specified conditions are designed to be semi-floating cable-stayed with the construction method of balanced cantilever erection construction.

The scheme of self-anchored suspension bridge is designed with a span of 380m without setting suspender in the side-span. Considering the controlling height of airport, the ratio of rise to span

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should be no more than 1:9 which is 1/6 smaller than common self-anchored suspension bridge's.

The scheme of new half-through prestressed steel truss-concrete composite continuous rigid frame bridge is designed with a span of 380m and the construction way is balanced cantilever erection. Variable cross-sections are adopted in the main truss along the bridge, with the truss heights of the top of the pier and mid-span being 42m and 10m respectively.

3. Characteristics of Half-Through Prestressed Steel Truss Concrete Composite Continuous Rigid Frame Bridge

In half-through prestressed steel truss concrete composite continuous rigid frame bridge, steel truss and steel-concrete composite are respectively used in different regions according to different mechanical requirements with steel truss tensioned while steel-concrete composite compressed. Analysis shows that the top segments of the bridge mid-pier are mainly subjected to negative moment with the upper tensioned and the lower compressed, therefore, steel box trusses with prestressed steel in tensioned steel pipe are used as upper chords which has already been applied in engineering before to avoid cracks while self-compacting micro expansive concrete is accordingly poured into lower chords to reduce the cost of steel, strengthen the stability of steel in compression, enhance the rigidity of structure. Otherwise, segments of mid-span are subjected to relative small positive moment restricted by the cantilever construction with the lower tensioned and the upper compressed thus steel box without pouring concrete are adopted to be compressed if possible in upper chords while lower chords combined with steel bridge deck are adopted to be tensioned.

4. Main procedure of construction

1. Install block zero and complete the consolidation between pier and steel truss.
2. Assemble the steel truss segments with cantilever method, pour bottom concrete timely and prestress the upper chords of steel truss
3. Assemble the steel truss segments with cantilever method, install the prefabricated bridge decks of side-span and mid-span and balance the weights of two cantilever ribs.
4. Complete the closure of bridge, pour the anti-corrosion materials into upper chords and complete the construction of bridge deck.

5. Conclusion

5.1. Comparison and Selection of Plans

Considering the restrictions of both navigation clearance and bridge height, three schemes for Rongjiang Bridge in Guangdong province are proposed in this paper. In the scheme of low-pylon cable-stayed bridge, the angles of the stayed-cables are small due to the limited height of the upper tower thus great sections are needed which is not economical and vertical components forces are relative small while horizontal components forces are relative large which makes negative influence on the mechanics. In the scheme of self-anchored suspension bridge, temporary stayed-cables have to be used to form the beams which has never been seen before and as the key technology suspender must be lengthened to complete the structure system transformation with high risky, expense, great difficulties and high maintenance cost. Basing on the comprehensive consideration, the third scheme of half-through prestressed steel truss concrete composite continuous rigid frame bridge is approved with shortened bridge height, good mechanics and perfect economic benefits.

5.2. Structure Characteristics

Steel-concrete composite continuous rigid frame bridge makes full use of steel and concrete with steel tensioned and concrete compressed significantly reducing the self-weight, avoiding the cracks and prestressed steel set in the upper chords can also save the cost of steel. Therefore, this new type bridge provides reasonable ways for long-span continuous rigid frame bridge with the superiorities of reasonable and definite mechanics, good reliability and stability and large spanning capacity.

5.3. Construction Characteristics

Fabricated construction is adopted for upper structure thus the construction equipment is simplified, the work time is shortened and the safety and quality are ensured simultaneously. Though this type of bridge is first comprehensively applied in engineering, the techniques referred to are mature enough and it is an integrated innovation basing on the research results on the existing bridge.