Research on Design Scheme of the Bridge Crossing Mekong River

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Abstract. A bridge will be built across the Mekong River in Luang Prabang Laos to maintain and enhance a vital transport link in the country, and to achieve successful development of road networks in northern region. Considering the topography, geology, hydrologic, navigation, construction and transportation conditions, the environment and the local culture characteristics, and by comparing the four design schemes, the recommended scheme of main bridge is designed as a cable-stayed bridge with double pylons and double cable planes, and with a main span 240m.

Introduction

The bridge crossing Mekong River under plan will connect Route 4B and Route 13 North in Laos; in the meantime, it is also the important access route connecting Luang Prabang Province in Laos and Nan Province in Thailand. Route 4B is the shortest access way connecting the northern part of Thailand to Luang Prabang. Route 13 North is the major road for traveling throughout Laos and connecting to other neighbor countries. Unfortunately, Mekong River flowing through Luang Prabang Province is a major natural obstacle between connections of these 2 important routes. Therefore, the construction of the bridge will not only improve local traffic conditions, but also will further promote the economic development of the northern part of Laos [1].

Technology standard

The bridge length is about 570m. Referring to Chinese design codes [2], the technology standard is show in Table 1.

Table 1. Project Technology Standard

No.	Name of Index		Technology Standard
1	Carriageway Design Class		Highway: Class Ⅲ
2	Design Speed		40km/h
3	Bridge Width		Main bridge：14.5m. The approach bridge：12.5m
4	Number of Lane		2
5	Design Load Standard of Bridge		Highway: Class Ⅱ
6	Layout of Bridge Section		2m（Sidewalk）+3.5m（Carriageway）+3.5m（Carriageway）+2m（Sidewalk）
7	Design Flood Frequency of Bridge	Super Grand Bridge	1/300
		Grand Bridge	1/100
8	Navigational Standard	One Bidirectional Navigable Bridge-Opening	120m（width）×10m（height）
		Two Unidirectional Navigable Bridge-Opening	60m（width）×10m（height）
9	Seismic Design		Basic earthquake intensity is degree Ⅷ.
10	Pavement Structure		Concrete

Current situation of bridge location area

The both sides of the bridge are flatland areas. Fig.1 shows that the geological condition at bridge location is fairly good. The subsurface condition is soft soil with stone bolder at the depth of 4～5m.

Fig.1. Physiognomy at Bridge Location

The bridge location area belongs to monsoon climate of tropical zone and subtropical zone, the annual average temperature is about 26℃, there is no clear distinction between the four seasons, the whole year is classified into rainy season and dry season, the period from May to October is the rainy season and the period from November to April of the next year is the dry season. The annual rainfall is 1250mm～3750mm.

Mekong River has 4880km of total main stream length and it is the most important transnational water system in Asia and the sixth longest river in the world. The highest speed of water flow at bridge location in Mekong River is 1.65m/s, the lowest speed is 0.72m/s. According to the record from 1980, the maximum water level is at +278m mean sea level with the maximum depth of 19.50m. The width of the river is 440m. The lowest water level during dry season is +262m above the sea level.

Bridge scheme design

According to navigational technology standard, it is required that the bidirectional navigable bridge-opening is 120m x 10m (width x height) and unidirectional navigable bridge-opening is 60m x 10m (width x height). From the point of view of ship bumping danger and actual navigation conditions, if one bidirectional navigable bridge-opening is used, then the main span should be no less than 150m. If two unidirectional navigable bridge-opening is used, the main span should be no less than 90m.

The water level changes remarkably at bridge location between rainy season and dry season. The water potential of the river is very complicated. Considering from the point of view of dredging analysis, big span should be used in the water to avoid influence on flood protection.

Considering the topographical and geological conditions, peripheral environment and local cultural characteristics, four schemes are proposed, i.e., extradosed cable-stayed bridge scheme, through concrete-filled steel tube arch bridge scheme, continuous bridge scheme, and cable-stayed bridge scheme.

Scheme Ⅰ: Extradosed cable-stayed bridge scheme

The extradosed cable-stayed bridge is a kind of bridge that belongs to a rigid-flexible combination system [3]. This scheme makes the upper pylon incline outward, therefore, it has enhanced the spatial stereovision of the pylon body and guy cable and it has made the upper pylon strike the eye, in the meantime, it has expanded the field of vision of the passengers in the vehicles and makes people feel wide and happy view while travelling. The impression drawing of this scheme is show in fig. 2.

Fig. 2. Extradosed Cable-Stayed Bridge

The main span of the bridge is (101+180+101) m. The bridge uses the structural form of tower and beam fixation. The pylon tower uses wing-spreading design scheme, the pylon height below the bridge floor is 25.2m and the outside measurement linearly increases from top down. The part above the bridge floor is upper cable pylon, the cable pylon inclines outward and forms 20 degree included angle to the vertical direction, the upper cable pylon height is about 20m. All pylons use box form section. The bridge has 96 suspension cables. Cable spacing on the girder is 5m, cable spacing on the pylon is 0.8m. The main girder structure is variable section pre-stress concrete box girder. The girder height at cable pylon is 6m， the mid-span girder height is 3m.

Scheme Ⅱ: Through concrete-filled steel tube arch bridge scheme

The through concrete-filled steel tube arch bridge has the characteristics of elegant modeling, mellow and full curve and richness in dynamic sense. The tied arch bridge has the feature of dispensing with supporting by foundation for horizontal pulling force of the arch rib; in the meantime, it will not block the river-routes. The impression drawing of this scheme is show in fig. 3.

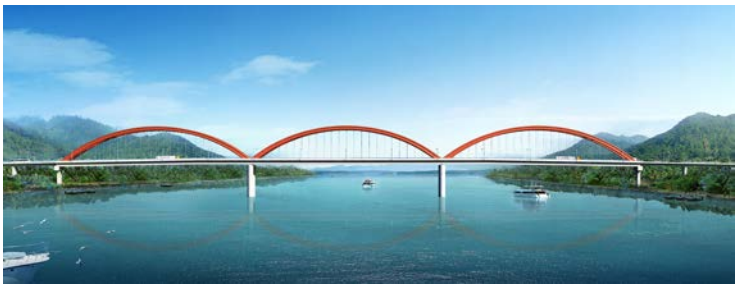

Fig. 3. Through Concrete-filled Steel Tube Arch Bridge

The main arch rib uses through type double-rib catenary arch [4], the calculated span is 127m，the calculated vector height is 25m，the ratio of rise to span is about 1/5. The arch rib height is 3m and the central distance between the two ribs is 10.5m. The standard spacing of suspender is 5m. The longitudinal beam of the bridge floor consists of two 2mx3m (width x height) single chamber structure, the cross girder height is 2.5m paved with concrete bridge deck. The substructure is a 3m diameter cylinder pier.

Scheme Ⅲ: Continuous bridge scheme

The line shape of continuous bridge is concise and clear with strong sense of rhythm with thorough field of view beneath the bridge. The originality of bridge pier comes from abstract figure of flower bud and it can fuse well with the box beam of the superstructure. The impression drawing of this scheme is show in fig. 4.

Fig. 4. Continuous Bridge

The main span of the bridge is 90 m. The superstructure of the bridge is prestressed concrete suspending cast box beam. The box beam is single-box single-chamber box-form section, both the box beam height and under-plate thickness change according to a second-degree parabola [5]. The bridge pies use double square column type, and the piers are equipped with transverse bracings.

Scheme Ⅳ: Cable-stayed bridge scheme

This scheme is a cable-stayed bridge with double pylons and double cable planes. The bridge pylons tilted inwards, and the sense of space level is enhanced. Slender and graceful pylons constitute a pair of pointed roof shaped structure, both close to the local folk architecture, but also have a good visual effect. The impression drawing of this scheme is show in fig. 5.

Fig. 5. Cable-Stayed Bridge

Considering the earthquake, wind load and live load, the bridge is designed as the semi floating structure [6]. The main span of the bridge is (100+240+100) m. The ratio of side span and mid-span of the cable-stayed bridge is 0.417, and the main beam is Main beam is designed to prestressed concrete structure.

The pylon height below the bridge deck is 30.6m, and the shape size increases linearly from top to bottom. The pylon height above the bridge deck is 60m, and the height-span ratio is 0.25. The pylons have pile foundations with 2m diameter, and cushion caps with 5m thickness. It reserves enough impact resistance in order to ensure the safety of ship navigation [7]. Considering topography, geology and beautiful modeling, the cable-stayed bridge scheme becomes the recommended scheme.

Conclusion

The bridge crossing Mekong River will be the first cable-stayed bridge in Laos. Therefore, it has a symbolic significance in the local area. The recommended bridge scheme not only meets the functional requirements, but also adapts to the construction level of the country. After more careful, rigorous design scheme comparison, finally a success scheme of a landmark bridge is proposed. The bridge has a beautiful appearance, reasonable layout, and the surrounding coordination, and so the ancient city will add a beautiful landscape. The bridge will be built to improve local traffic conditions, and the successful realization of the bridge can also provide examples for the design and construction of similar bridges.

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