Hangzhou Bay Bridge

LOCATION:

Ningbo-Jiaxing, China

SUBMITTING FIRM:

CCCC Highway Consultants Co., Ltd.

FIDIC MEMBER:

China National Association of Engineering Consultants (CNAEC)

The Hangzhou Bay Cross-Sea Bridge is located at the mouth of Hangzhou Bay, which is one of the world's three largest bays with strong tidal. From the earliest stages, the bridge's designers put forth an innovative and locally-sensitive engineering plan. The bridge's vertical alignment is inspired by the gentle arches of the Northern Song Dynasty's Su Causeway, an important cultural symbol at the UNESCO Heritage Site of West Lake. The flowing, rhythmic wave-like pattern not only adds visual intrigue to the concrete structure, but also allows sufficient clearance for maritime navigation and bridge maintenance.

The magnitude of the bridge's construction, combined with unique environmental conditions, posed numerous challenges to project delivery. Due to unique tidal conditions in Hangzhou Bay and seasonal bad weather, effective construction time for the bridge's second section was less than 180 days per year. Hangzhou Bay features one of the world's largest tidal bores, with incoming waves sometimes reaching as high as nine feet. This unique hydrologic feature posed serious challenges to the construction of the bridge. In order to minimize the offshore workload, many bridge components were fabricated in factories and transported and installed using large ships and barges with hoisting crane installation equipment. Prefabrication of bridge components not only improved the quality of construction but also reduced project risk by maximizing workers' safety.

Geologic and water quality issues also impacted the bridge's structural design. Following the principle that "the structure design is the soul of a structure's durability," the bridge's design was developed to allow significant opportunities for design, construction and maintenance

reviews. Because the Hangzhou Bay Cross-Sea Bridge is in a challenging marine environment, special attention was e paid to the durability of construction materials. In order to improve the concrete's resistance to permeation by chloride ions, protective coatings were added to the concrete.

The Hangzhou Bay Cross-Sea Bridge enhanced technical innovation during the construction process and has resulted in a number of advances with respect to independent intellectual property rights. The Hangzhou Bay Cross-Sea Bridge represents the latest technical achievements in Chinese cross-sea bridge construction and is recognized worldwide as a landmark in bridge design and construction effort. Construction of the bridge entailed 148 scientific research studies in the design and construction fields, as well as more than 250 technical innovation achievements and numerous world records. These achievements laid a solid foundation for the successful completion of the bridge. The bridge has led to 25 patent filings, one state-level method, and eight provincial and ministerial level methods.

The bridge's technical achievements have won the Chinese National Progress Prize in Science and Technology and other science and technology awards. Design and construction techniques developed on the Hangzhou Bay Cross-Sea Bridge have been applied on many major projects both in China and abroad, including the Ningbo Xiangshan Island Bridge, the Zhoushan Islands Project, the Shantou Nan'ao Bridge, the Fujian Pingtan Strait Bridge, the Qingdao Bay Bridge and South Korea's Incheon Bridge.

The Hangzhou Bay Cross-Sea Bridge construction has become a model of technical excellence and innovation in the field of engineering. For the 10-kilometer-long shallow beach on the south bank, the method of "transporting girder on girders" for 50m long box girders increased the transport weight from 900 tons to 1430 tons, setting a new record for bridge construction with the same technology and land area. The superstructure of the bridge in deep sea area uses 70m precast prestressed concrete box girders that were fabricated onshore and transported and erected onsite. In order to prevent cracking during the early stages of

construction, these segments employed a pioneering approach involving a combination of pre-stressing and post-tensioning methods.

In addition to the unique superstructure construction methods, the Hangzhou Bay Cross-Sea Bridge demonstrated a number of innovative substructure features as well. The bridge's steel pipe piles measure 1.6m in diameter, with a maximum length of 89m and a maximum weight of 74 tons per individual pile, making them the longest large-diameter spiral steel pipe piles in the country. Vast fields of biogas in the 10km intertidal area on the bridge's south bank required special construction techniques to increase stability. Biogas was released in a controlled method that can be used as a model for bridges in similar geologic areas around the world. These innovations and applications of technology have effectively supported the construction of Hangzhou Bay Cross-Sea Bridge, resulted in a number of engineering firsts, and generated valuable data and experience in the design and construction of sea bridges.

Sustainable development was a central tenet in the design and construction of the Hangzhou Bay Cross-Sea Bridge. The bridge boasts a real-time online structural health monitoring system with a total of 1,356 monitoring points and 890 sensors for load and structural response monitoring. This system allows the bridge to be scientifically monitored and easily maintained and managed. The bridge is a "digital bridge." The design and scientific research companies involved set up a scientific evaluation system for the design, construction and maintenance of the bridge using multidisciplinary technology, such as network and database technology, graphics technology, artificial intelligence technology, computational mathematics, finite element technology and mechanics. During the construction period, monitor was set up per kilometer for the length of bridge. During six years of operating and monitoring of the bridge, it has been shown that the bridge structure displacement and stress levels are both within the expected design ranges. The bridge functions in a flexible working state and the structure's performance meets all engineering and construction requirements.

The project management consulting, bidding and procurement practices of the Hangzhou

Bay Cross-Sea Bridge adhere to FIDIC's principles of transparency. The project management team adopted models of contract and quality management to effectively coordinate the dozens of research, consulting and construction companies involved in the project. In addition to ensuring the engineering quality, progress and investment control management targets were met, the project team for the Hangzhou Bay Cross-Sea Bridge focused significantly on workforce development and safety. The project resulted in training opportunities for a large number of engineering consulting and management personnel, and received a safety distinction from the Ministry of Transport and the State Administration of Work Safety for projects valued at more than 10 billion yuan with zero fatalities. The document for recognition of the new safety record was awarded on April 25, 2008.

The average daily traffic volume of the Hangzhou Bay Cross-Sea Bridge has been more 50,000 passenger vehicles since 2010. The bridge promotes the integration of the Yangtze River Delta region and the implementation of the coastal development strategy, expands the economic influence of Shanghai, greatly reduces fuel consumption and travel time between key cities in the Yangtze River Delta region, promotes the economic development of Ningbo, and upgrades the region's industrial structure on both sides of the bridge