Sustainability through Innovation in Design and Construction –Second Penang Bridge, Malaysia

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Summary

Jambatan Kedua Pvt. Ltd. (JKSB), a wholly-owned company of the Malaysia Ministry of Finance, Incorporated is the concessionaire for the Second Penang Bridge Project (PB2X). The bridge with estimated cost of RM4,5 billion is set to be the longest in South-East Asia with a total length of 16,9 km over water. The construction of PB2X commenced in November 2008 and is to be completed by September 2013. It has faced various challenges in applying sustainability to both design and construction. The PB2X is pioneering in Malaysia to be fully designed for seismic load for a 475 year return period earthquake and a 2500 year return period earthquake with 'no collapse' criteria.

Keywords: segmental box; cable stayed; bored pile; spun pile; earthquake; no collapse; high damping rubber bearing; pylon; thermal crack; navigation span.

1. Introduction

The P2BX linking Batu Maung in Penang Island and Batu Kawan in Seberang Prai when completed will improve trade efficiency and enhance logistics systems by providing better connectivity and accessibility to Penang International Airport. The bridge is aimed to alleviate the current overloaded traffic at the existing bridge and to meet the future traffic demand, apart from being one of the key elements in the development of Penang as logistics and transportation hub for the northern region of Malaysia under the Northern Corridor Economic Region program.

2. Project Description

JKSB was appointed the concessionaire for PB2X in August 2008 for period of 45 years. It is responsible for the project management, design, construction, operation and maintenance. PB2X is divided into few packages namely Packages 1 and 2 consisting of marine bridge and Package 3 consisting approaches to the marine bridge. The main span over navigation channel consists of 3-spans twin-tower fan-type cable stayed bridge of span length 117,5m+240m+117,5m whereas the approach bridges on both sides consist of 55m span continuous precast segmental box girder. Two separate two lanes carriageways each having total width of 14,4m is adopted for Approach Bridge.

3. Sustainable Development

JKSB has undertaken the lifecycle management of PB2X where sustainable development and green technology are key to build the future. Sustainable development is enduring balanced approach to social progress, economic activity and environmental responsibility. The emphasis to a lowest 120 years design life cost is to promote the concept of design for durability. Durability is mainly influenced by the factors [1] such as design and detailing, specification of materials used in construction and quality of construction.

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In effort to conserve natural resources and protect the environment, high standards of environmental protection were incorporated into the project. Marine fauna were closely monitored to avoid changes to the sensitive marine environment. In the feasibility study, alternative alignments considered are the Northern Route, the Mid-Channel Route and Southern Route; with the Northern Route the highest Internal Rate of Return (IRR). The alignment of the Southern route was chosen as to promote socio-economic development in the south.

Most of the bridge sections such as tubular steel piles, precast spun piles, reinforcement caging, precast shell, steel fender and segmental box girder utilized Industrial Building System (IBS) and are prefabricated on land to reduce the amount of time spent at sea and the risks of damaging or polluting the marine environment. The segmental box girders (SBG) were optimally designed for minimum weight and lesser embodied energy by adopting higher strength concrete [2]. The use of external and internal pre-stressing increases design economy. All concrete used are of high performance concrete with Rapid Chloride Permeability Test (RCPT) < 800 coulombs in 56 days. The concrete cover & crack width conform to latest Eurocode requirement. Fly ash-based green cement is used for low temperature rises of the pilecaps and piers to reduce risk of thermal cracking during concreting. Silane coating is applied to precast concrete spun piles, pilecap and pier concrete surface in contact with sea water to further reduce the water and salt intake that can cause corrosion to the embedded reinforcement. The bridge articulation uses high density rubber bearings (HDRB) for seismic protection. HDRB uses natural rubber, possess high damping properties and lower embodied energy. Cable saddles are used for stay cables to continue over pylon to reduce the pylon size & improve the bridge aesthetics. The steel fender system is adopted over man-made island for its environmental friendliness, less impact on water flow, cost saving & shorter construction period.

The geotechnical design of the land expressway complies with 100% primary consolidation and a settlement requirement of 50mm in 20 years. Embankments are to be compacted to not less than 98% of the optimum dry density using the modified compaction test.

Stringent quality controls in accordance to project specification were enforced to ensure minimal maintenance. The best practice was adopted for the construction including equipment selection and working method statements. Periodic site audit are done by the Independent Checking Engineer.

The dredging of the 270m wide construction channel involving 14 million cubic metres of the Great Kra Flats seabed. The sludge was disposed off Pulau Kendi by barges installed with satellite tracking, trap door and depth sensor devices.

A monthly environmental monitoring audit is done by and independent Environmental Impact Assessment (EIA) consultant. Quarterly fisheries impact assessment for marine and fisheries resources including aquatic environment and aquaculture are also done. Structural Health Monitoring System (SHMS) shall be used for preventive maintenance to assess the state of health (e.g., damage) of the structures. It improves safety and reliability of the bridge by detecting damage before it reaches a critical stage.

4. Conclusion

The implementation of this fast-track project particularly on its construction techniques shall be exemplary and reference to other upcoming bridge constructions of its kind. The execution of Design & Build concept for the major portion of the project is anticipated to produce impressive results and lead to many innovations as well as promoting a cost-effective bridge engineering and maintenance practice in Malaysia. JKSB is committed to complete the project with the highest quality, timely delivery and within the budgeted cost to contribute towards sustainable development.

5. References

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