Construction of the Bai Chay Bridge

Kazuteru TSUCHIDA
Design Manager
Shimizu Corporation
Tokyo, JAPAN
k-tsuchida@shimz.co.jp

Hiroshi OHNO
Deputy General Manager
Shimizu Corporation
Tokyo, JAPAN
Hiroshi-ohno@ shimz.co.jp

Tomoki NAKAMURA
Construction Manager
Shimizu Corporation
Tokyo, JAPAN
Nakamura.tomoki@shimz.biz

Toshihiro WAKAHARA
Chief Research Engineer
Shimizu Corporation
Tokyo, JAPAN
t-wakahara@ shimz.co.jp

Naoki NAGAMOTO
Design Manager
Sumitomo Mitsui
Construction Co., Ltd.
Tokyo, JAPAN
nagamoton@smcon.co.jp

Masahisa KOMIYA
The Engineer
Japan Bridge & Structure
Institute, Inc
Tokyo, JAPAN
k-hayashi@jbsi.co.jp

Summary

The Bai Chay Bridge, spanning a strait within sight of Ha Long Bay, Vietnam's premier World Heritage site, has the world's longest center span length of 435 m, as a single plane cable-stayed prestressed concrete bridge, with a bridge length of 903 m.

The foundations for the main piers were constructed by the pneumatic caisson method. Form travelers were used for the cast-in-situ box girder erection by the balanced cantilever method. The main pylons, which extend 91,5 m in height above the deck level were constructed using a climbing formwork system.

The box girder is lightweight with internal steel pipe bracing and prestressing tendons. The design wind speed for the bridge is 50 m/s. Technologically advanced vibration control devices for the stay cables and the pylons were incorporated into the construction.

Keywords: Single plane cable-stayed prestressed concrete bridge; Box girder with steel pipe bracing; World's longest span; Vibration control devices; Ha Long Bay; World Heritage.

1. Introduction

National Highway No.18 (total length 319 km), which connects the international airport of the capital city, Hanoi, with the town of Mong Cai on the Chinese border, has long been interrupted at almost its mid-point by a narrow strait in Ha Long Bay. The Bai Chay Bridge spanning this strait has been built with a loan provided by the Japan Bank for International Cooperation (Fig. 1). The navigation clearance beneath the bridge is 200 m in width and 50 m in height. As the piers are constructed in the shoreline, not in the strait, the Bai Chay Bridge has an aesthetic feature that naturally merges it with the surrounding scenery.

2. Construction

2.1 Outline of Construction

The main pier foundations were constructed by the pneumatic caisson method. The other foundations were constructed by caisson pile method. For the construction of superstructure, form travelers were used for the cast-in-situ girder erection by the balanced cantilever method, concurrently with the construction of the pylon and erection of the stay cables.

Fig. 1: Bai Chay Bridge

https://doi.org/10.2749/222137908796292092

2.2 Construction of Superstructure

The prestressed concrete box girder, constructed in segment lengths of 6,5 m, is lightweight in nature with additional rigidity being provided by internal steel pipe bracing (Fig. 2). Prestressing tendons were installed in the square steel pipe brace to resist the tensile force of the stay cables at their anchorage locations. The center span side of the box girder consists of 32 segments. A typical cycle time for casting of a pair of new segments was eight days.

Construction of each pylon was divided into twenty four lifts. To maximize speed and quality of concrete finishing, a climbing formwork system was utilized.

Fig. 2: Internal Steel Pipe Bracing

Each main pylon incorporates 56 stay cables with individual stay cables consisting of 35 – 71 strands installed inside a HDPE duct. The ducts, known as Compact Ducts, are 20% less in diameter than standard ducts. This reduced diameter decreases the projection area of the ducts. After erection of the HDPE duct and a master strand (firstly installed strand), strand by strand installation commenced at the bottom of the stay cable.

3. Detailed Design and Testing

Strength of the square steel pipe brace was tested using 1/2-scale model, which was modelled with concrete web and lower slab. The test results showed that the square steel pipe brace and the anchorages of prestressing tendons had enough strength against the vertical force of the stay cable at ultimate limit state.

In order to satisfy a safety factor of 1,3 for the wind load at the mean wind speed of 50 m/s, together to minimize the possibility of cracking at the mean wind speed of 45 m/sec., vertical prestressing tendons and high-strength large-size reinforcement were installed in the lower sections of the pylon. Moreover, a total of 344 Tuned Liquid Dampers were installed in each pylon. Vibration testing of the pylon showed that the logarithmic decrement of damping in the first mode increased from 0,03 to 0,07 and the dynamic acceleration response of the pylon decreased by 58%.

Vibration control of the stay cables was achieved by the installation of dampers at the deck level. The types of installed dampers were varied according to the length of the stay cable. Internal Radial Dampers were utilized for the 40 longer cables. Vibration tests of the stay cables showed that the logarithmic decrement of damping in the first to the third modes increased from around 0,005 to 0,03 – 0,04.

Wind tunnel tests, using a 3D-full bridge model scale 1/150, were carried out at the University of Tokyo to examine the bridge’s structural stability against high winds (Fig. 3). The results obtained from the testing showed that aerodynamic instability would not occur.

Fig. 3: Wind Tunnel Test

4. Conclusions

The Bai Chay Bridge was opened for traffic in early December 2006. Completion of the bridge will not only enhance tourism to the World Heritage site of Ha Long Bay located close by, but will also improve trade links between Vietnam and Southern China, thus encouraging further development within the region.