Nhat Tan Bridge in Vietnam

— Bridge Design and Substructure Construction —

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Project Outline

The Nhat Tan Bridge project represents an 8.5-km highway construction project that crosses the Red River and extends south to north in Hanoi, the capital of Vietnam. The project commemorates the 1,000th anniversary (October 2010) of Hanoi being established as the nation's capital. The new bridge is a cable-stayed structure with five main towers and is expected to become a symbol of friendship between Vietnam and Japan.

Design and project execution control are undertaken by a joint venture of Chodai Co., Ltd. and Nippon Engineering Consultants Co., Ltd. Construction package 1, including construction of the main bridge, is being undertaken by a joint venture between IHI Corporation and Sumitomo Mitsui Construction Co., Ltd. and is financed as a yen-based STEP (Special Term for Economic Partnership) loan, a special Japanese government ODA loan. Construction work started in October 2009.

The following introduces mainly the design and construction of the steel pipe sheet pile well foundations adopted for the tower foundations of the main bridge.

Plan and Design of the Nhat Tan Main Bridge

● Bridge Outline

—Project owner:
  Ministry of Transport of Vietnam, Project Management Unit 85
—Bridge length: 1,500 m
—Length of Spans:
  150 m + 4 × 300 m + 150 m
—Type
  Superstructure:
    Six-span continuous composite dual I-girder cable-stayed bridges
  Slabs:
    Precast reinforced concrete slabs
  Main towers:
    Reinforced concrete A-shaped towers
  Foundations:
    Steel pipe sheet pile well foundations
(Refer to Figs. 1~2)

● Selection of Bridge Type

The Red River flows west to east, and in the

Fig. 1 Section of Superstructure

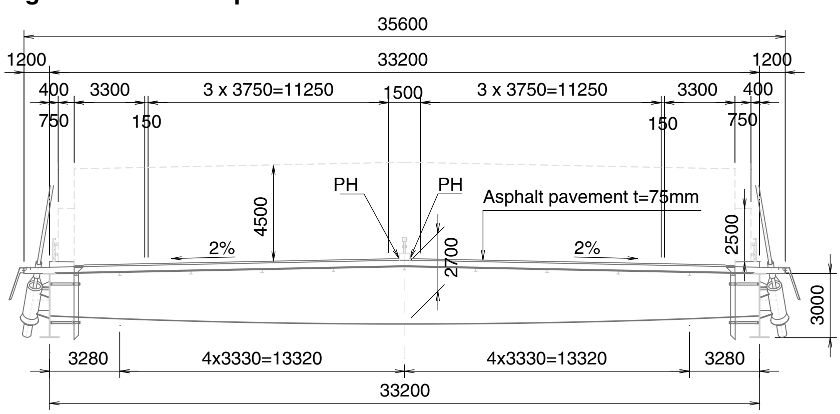


Fig. 2 General Drawing of P12 Main Tower

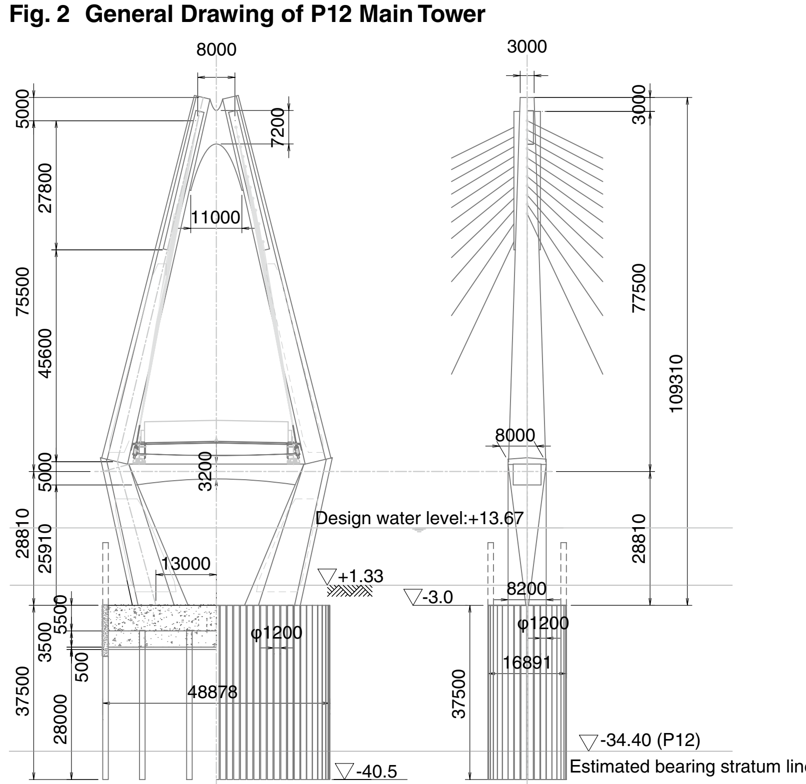


Fig. 3 Elevation of Entire Bridge

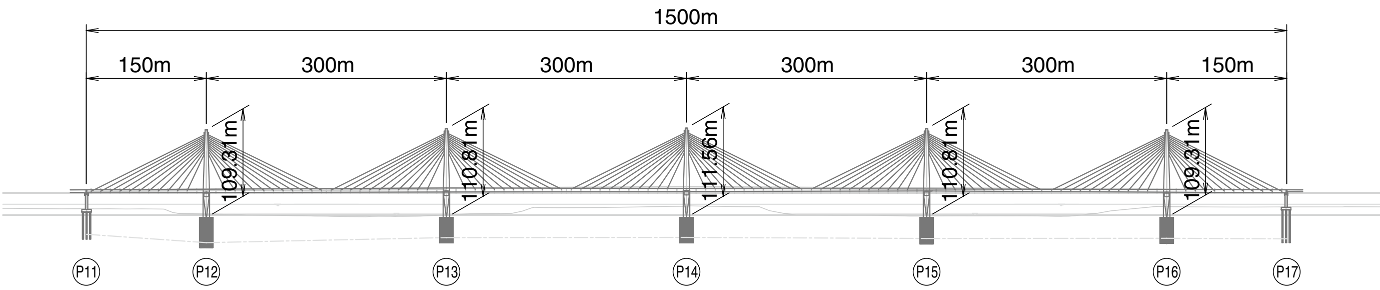


Fig. 4 Perspective of Nhat Tan Bridge upon Completion (Computer Graphics)

(Courtesy: Sumitomo Mitsui Construction Co., Ltd.)

vicinity of the bridge construction site it is separated into two channels that sandwich a sandbar. According to the historical record, the riverbed is known to change over time with regard to the location of the river channels and the sandbar. Because of this, future movement of the river channels and sandbar were taken into consideration in selecting a six-span continuous cable-stayed bridge plan having spans of equal length (Figs. 3, 4).

● Applied Standards

The bridge design conforms to the *Specification for Bridge Design 22TCN-272-05* of Vietnam, which is based on the AASHTO-LRFD of the U.S. Further, such items as steel pipe sheet pile well foundations and base-isolated bearings, which are not described in the Specification, followed specifications in the design standards of Japan.

● Major Structural Materials

The major structural materials are as follows:

—Steel products:
  SS400, SM400, SM490, SM490Y, SM520, SM570

—Cables:
  Parallel strands using 7 mm-diameter galvanized steel wire (tensile strength: 1,770 MPa)

—Steel pipe sheet piles: SKY400, SKY490

—Design standard strength of concrete:
  40 MPa (main tower, slab); 30 MPa (end piers, cast-in-place piles); 25 MPa (top slab of steel pipe sheet pile foundations)

—Reinforcing bars: SD390

—PC strands: SWPR7BL

● Road Composition

The road is composed from its center: two automobile lanes (3.75 m wide), a bus lane (3.75 m wide), a dual-use motorcycle-bicycle lane (3.3 m wide), and a walkway (0.75 m) along the outer edge.

● Superstructure

The superstructure is a continuous structure spanning 1,500 m in total length. The main structure consists of two main I-girders located along each edge of the roadway to which cross beams to support the slabs are arranged at 4-m intervals. The cables are anchored to the outside surface of the main girder webs. The main girders and cross beams form a composite girder structure to which precast slabs are connected using dowels. Fairings are installed on the outer edges of the slabs to improve wind stability.

The cables employing parallel wire strands are arranged in a fan-shaped form, and the girders are suspended in a double-plane format from the main towers.

● Main Towers

The reinforced-concrete main towers adopt an A-shaped structure to secure rigidity perpendicular to the bridge axis. Below the crossbeams that support the superstructure, the support columns of each tower draw steadily inward as they descend, thereby narrowing the space between the columns in order to decrease the plane shape of the foundation.

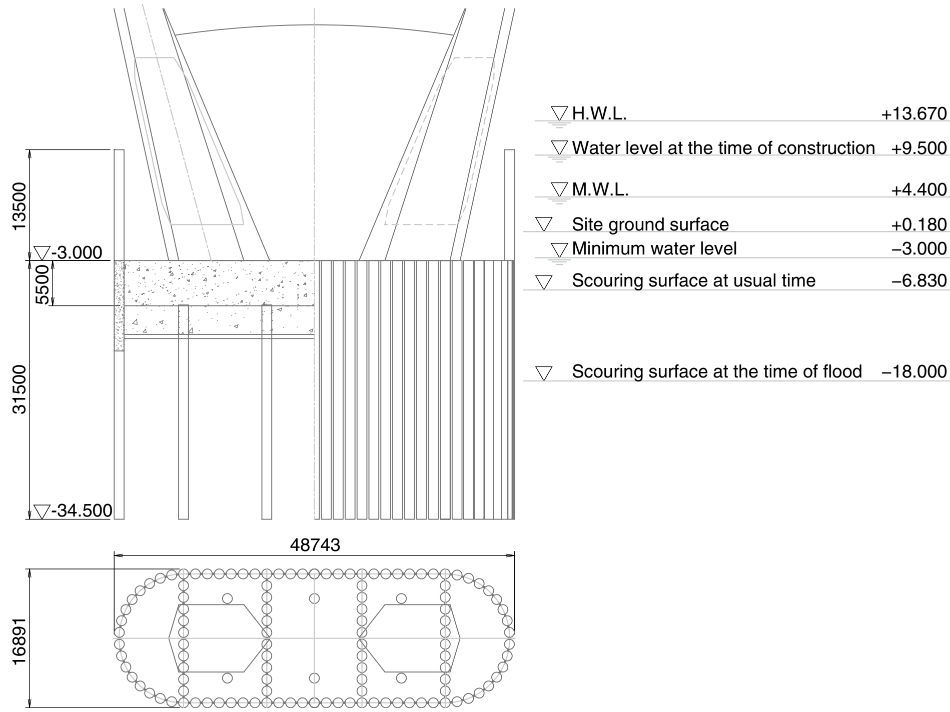
Because axial tension force works on the crossbeams, a prestressed concrete structure was adopted. Anchor boxes employing steel plates are embedded near the top of the tower, and the cables are anchored to the bearing brackets within the boxes.

● Steel Pipe Sheet Pile Well Foundations

With the aim of improving upon the construction quality of cast-in-place piles that have occasionally offered application concerns in Vietnam, steel pipe sheet pile well foundations were adopted for the first time in Vietnam. Because this type of foundation was developed in Japan, two Japanese specifications were adopted for design and construction—*Specifications for Highway Bridges IV* (2002) and *Design and Construction Manual for Steel Pipe Sheet Pile Foundations* (1997).

The scouring depth accounted for in the design was estimated to be, at maximum, 15 m from the riverbed. The driving method for pile installation was adopted with the aim of securing bearing capacity. The

Fig. 5 Schematic Diagram of P13 Foundation



piles were to be embedded in the bearing stratum, a gravel layer with N>50, to a depth more than five times the pile diameter. The top surface of the top slabs was set at a position equal to sea level –3 m, taking into account changes in the riverbed.

The adopted pile diameter was 1,200 mm, and the wall thickness of the piles is 16~21 mm. The well foundations have an oval plane shape with the dimensions of 48.7 m x 16.9 m. The maximum length of the steel pipe sheet pile well foundations, including temporary cofferdams, is 50 m. The number of pipe piles used, including the bulkhead and internal piles, amounted to 632. The reinforcing bar stud method was adopted for connecting the top slabs. (Refer to Fig. 5)

Photo 1 Full view of construction site

Photo 2 On-land construction at sandbar

Progress in Construction

At the end of May 2011, construction of the main tower foundations was underway at P13~P15; and driving of the steel pipe sheet piles was completed and underwater excavation, installation of the lower slabs and upper slabs, etc. were underway at P12 and P16. (Photos 1, 2).

● Execution Yard and Machinery

The sandbar in the Red River where P14 is being constructed is utilized as a structural material yard, reinforcing bar fabrication yard and emergency evacuation base. At P12, P13 and P15, which are located within the river, underwater construction is being conducted using a crane ship, material transport and other barges (Photo 3).

● Driving of Steel Pipe Piles

In order to construct large-scale foundations and to drive and close steel pipe sheet piles with a maximum length of 50 m, it is important to execute precise vertical driving of the piles. At the construction site, the pipe piles were driven using hydraulic vibratory hammers in combination with the

Photo 3 Barges used for underwater construction

Photo 4 Water jetting nozzle

Photo 5 Final driving of steel pipe piles using diesel hammer

water jet method. This driving method was applied to drive piles up to a depth of 6D (D=pile diameter) above the pile tip, whereas final driving into the bearing stratum was undertaken using diesel hammers. (Refer to Photos 4, 5)

One test pile was driven for each foundation, and the bearing capacity was con-

Photo 6 Interior of well foundation

Photo 7 Discharge hole of underwater drilling pump

firmed by means of PDA (pile driving analyzer).

● Temporary Cofferdams

In the design stage, historical water level data for the Red River was relied upon to set the water level at the time of construction at sea level + 9.5 m, excluding the two months in summer when the water rises to its maximum level. Because of the large difference in water heads, various measures were taken to reduce the residual stress on the driven piles. These included studies and improvements for multi-step timbering, water level regulation, arrangement of the bottom slab placement period and other devices.

During the actual work, the water level rose to sea level + about 7 m due to water

Photo 8 Full-scale model prepared to examine installation of reinforcing bar cage for main tower bottom section

shortages in 2010. Because of this, construction work continued without interruption even during the summer season, moreover, it was possible to lower the height of the cofferdam by 1 m below the design level.

● Underwater Excavation

The method adopted to conduct underwater excavation inside the steel pipe sheet pile well was using pumps to discharge both water and riverbed sand (Photos 6, 7).

● Subsequent Processes

After excavation, underwater placement of the bottom concrete slabs, stud welding, reinforcing bar arrangement and concrete placement of the top slabs will be undertaken; following this, the main towers will be constructed. These subsequent processes will be introduced at the next opportunity. (Refer to Photo 8)

High Expectations for Japanese Technologies

The next two and a half years will see the continuation of on-site, high precision construction work, such as construction of the main towers, installation of the anchor boxes at the top of the towers and cantilever erection of the main girders. We expect that, by capitalizing on Japan's advanced technological capabilities, the Nhat Tan Bridge will be safely completed and opened to traffic, and that the bridge will contribute to the development of the Vietnamese economy.

Acknowledgments

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