Continuous Arch Bridge in Seto Inland Sea
— Otagawa Ohashi Bridge, Hiroshima —

瀬戸内に映える 2 連のアーチ
— 太田川大橋 —


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* Yoko KABAKI, P.E.Jp: Eight-Japan Engineering Consultants Inc.
椛木　洋子，技術士（総合技術監理部門，建設部門）：（株）エイト日本技術開発
** Akiyoshi NII, Ph,D: Kokushikan University
二井　昭佳，博士（工学）：国士舘大学　准教授
*** Ken KOBAYASHI, P.E.Jp: Shimizu Corporation
小林　顕，技術士（建設部門）：清水建設（株）
**** Toshimitsu MAEDA: Shimizu Corporation
前田　利光：清水建設（株）
Contact: kabaki-yo@ej-hds.co.jp

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Fig.1 Otagawa Ohashi Bridge, Hiroshima

Synopsis

In Hiroshima city, Hiroshima prefecture, Japan, the Otagawa Ohashi Bridge was constructed and opened for public use in March 2014. The selection of the bridge design was conducted through an international design competition held in 2009, and the final winning proposal, the one presented here, was chosen for implementation and construction.

The main design concepts were to match the bridge line with the beautiful Seto Inland Sea and riverside scenery, make a gently sloped walkway for pedestrians without steps, and form a smooth connection with the neighboring western viaduct.

The authors and contractors are very honored to have had such a major opportunity to design and build a memorable structure in such a beautiful atmosphere.

Structural Data

Structure: 6-span continuous steel–concrete composite arch bridge
Bridge Length: 412.0m
Span: 46.5m + 116.0m (arch) + 116.0m (arch) + 47.0m + 46.5m + 40.0m
Width: 22.5m (pedestrian walkway: 4.0m)
Arch Rise:14.5m
Owner: Hiroshima City, Japan
Designer: Eight-Japan Engineering Consultants Inc., Akiyoshi NII, EAU Ltd.
Contractor: Shimizu Corporation
Construction Period: Oct. 2011 – Mar. 2014
Location: Hiroshima Prefecture, Japan

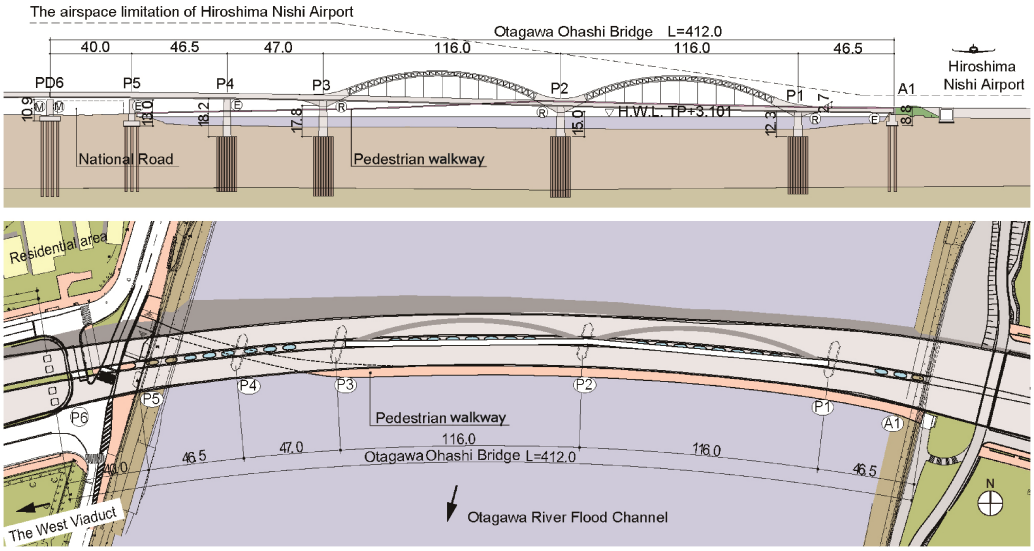

Fig.2 Elevation and plan of Otagawa Ohashi Bridge

1. Introduction

In 2009, an international bridge-design competition was held in Hiroshima, Japan, with the participation of 21 design firms, including firms from Spain and France. The authors' proposal was selected as the winner and became the enforcement plan for the detailed design work and supervision. Otagawa Ohashi Bridge is a steel–concrete composite arch bridge over the Otagawa River Flood Control Channel in Hiroshima City.

After strenuous construction and erection work, the bridge was opened for public use in March 2014. It is now providing proper service, and its beautiful arch shape gives good scenery for both motorists and pedestrians.

The bridge was fortunate to be awarded the Japan Society of Civil Engineers (JSCE) Prize in 2015 and also won the JSCE Grand Prize for good design in 2017.

2. Design

(1) Aesthetic Design

To establish the design concepts for this bridge, the authors settled on the following three characteristics: 1) matching aesthetically with the surrounding environment, 2) a gently sloped pedestrian walkway without steps, and 3) smooth continuity with the western viaduct. The two main arches formed a new beautiful landscape with the Itsukushima Island mountains and the Seto Inland Sea as the bridge background. In addition to the overall view, several specific items were considered in detail, namely bridge illumination, a resting space with stone chairs on the pedestrian walkway, and bridgehead plazas on both river banks. These play important roles in the bridge aesthetics.

(2) Structural Design

Based on the bridge planning and aims, detailed studies of the Otagawa Ohashi Bridge including the pedestrian walkway and western viaduct were conducted. Making full use of a 1/50 scale model and partial models from

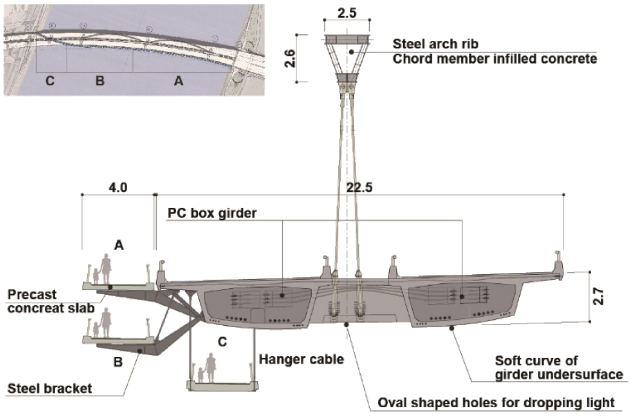

Fig.3 Main girder and arch cross section

1/1 to 1/100 scale, detailed analytical and practical studies were conducted efficiently to determine the cross-sectional shape and main arch structure. By carrying out this form of precise examination, deep consideration and enthusiastic discussion took place regarding planning and constructing the bridge.

The Otagawa Ohashi Bridge is a 6-span continuous steel–concrete composite arch bridge that is effectively a Prestressed-Concrete (PC) continuous rigid-frame box-girder bridge stiffened mainly by a steel arch. It has a slender shape in which the girder is kept at a constant height by load sharing with the main girder and arch structure. The main arch structure is arranged in the median strip between the inbound and outbound lanes, and the arch base is connected rigidly to the piers and the main girder in the fin back structure.

As for the structural design of the pedestrian walkway, to make the walkway more enjoyable to walk on, the design team decided to separate it from the main body of the bridge and to link on both bridge ends to the river banks directly without steps. Doing so achieved a gently sloped pedestrian walkway with views of the beautiful Seto Inland Sea scenery all along its length. Wind tunnel tests were also conducted to ensure a high level of safety for the walkway in strong winds [1] [2].

Fig.4 Construction of the arch structure by barge

3. Construction

(1) Construction of Brackish-Water Area

The non-flooding period of the Otagawa River Flood Control Channel is between October 26 and June 10. Most of the construction work took place during that period, with temporary facilities installed on the riverbanks. All six substructures, A1 to P5, were constructed on the riverbanks. The bridge construction site was 200m from the estuary, and the work proceeded by considering the maximum tidal difference of three meters in the Seto Island Sea, which is noted for its considerable tidal variations (**Fig.5**).

(2) Construction of Assembled Arch's Main Structure on a Barge

The water at the construction point was up to five meters deep, which made it difficult to use large crane barges to construct the main structures of the two arches. Instead, each structure was installed in an assembled state on a barge equipped with lifting jacks to balance the tidal ebb and flow. The work schedule for the balanced cantilever erection was coordinated to avoid interference among the main arch structures, main girders, and form travelers. The tidal sea conditions restricted the working days and times, making it necessary to develop an elaborate construction plan (**Fig.4**).

(3) Super Quality Concrete Infilled for Arch's Main Structure

The main structure of each arch is a truss frame (braced rib-arch main structure) comprising upper and lower cord members with a steel box section and square steel-pipe diagonal members arranged in a V shape (**Fig.3**). The interior of the box section (cell) had to be filled with self-compacting high-strength and high-

Fig.5 Construction of superstructure with work barges

durability concrete (80 N/mm^2) to improve the buckling resistance and fatigue characteristics. However, because of constraints on the on-site operations and the site conditions, the filling operation required the concrete to be transported pneumatically over a distance of 300m. As such, before work began, a test was conducted using a full-size mockup to find a concrete composition that could be transported pneumatically and would provide the necessary infilling performance.

(4) Ultra-Short Work Schedule

The 412-m-long bridge and its walkway were constructed in a very short period of 30 months, including the superstructure, substructure, and the inbound and outbound lanes. In addition to the

Fig.6 Panoramic view from the right bank downstream

constraints imposed by the river and the special structure of the main girders, the project involved many special construction methods, such as installing bracket materials in the attached walkway, using barges to construct the assembled arch, filling the main arch structures with concrete, connecting both lanes, and supporting the main girders from the main arch structures. Thus, the schedule was very challenging.

Fig.7 The bright pedestrian walkway alongside of the main bridge

4. Conclusion

The Otagawa Ohashi Bridge is a 6-span continuous steel–concrete composite arch bridge with a unique structure selected by an international design competition. The sub- and super-structure of this 412-m-long bridge were constructed in a short period of only 30 months by a large block erection system using barges for the two main arch structures in cantilever erection.

The project, including additional bridge surfacing, was completed in March 2014 and the bridge became operational on the 23th of the same month (**Figs.6, 7**).

To date, the bridge has won the Tanaka Prize of the JSCE and awards from the Japan Prestressed Concrete Institute and the Japan Concrete Institute.

References

[1] Akiyoshi NII, Yoko KABAKI, Sota ANIYA, et al., *Planning and design of Otagawa Ohashi Bridge in Hiroshima*, IABSE Conference 2015, Nara, Japan.

[2] Akiyoshi NII, Yoko KABAKI, Kenichi NISHIYAMA, Sota ANIYA, *The importance of bridge planning in bridge design*, 5th International Congress of IASDR, August 2013, Tokyo, Japan.

概　要

太田川大橋は，広島市の湾岸部に位置する広島南道路のうち，太田川放水路の最下流部に架かる橋梁であり，国際デザインコンペにより選定された特徴的な構造を持つ６径間連続鋼・コンクリート複合アーチ橋である。

橋長412m の上下部工（上下線）を張出し架設の途中でアーチ主構を台船一括架設し，吊ケーブルにより懸垂しながら施工するとともに，併設する自転車歩行者専用橋を含め，わずか30ヵ月という短期間で架設する超急速施工であった。鋼アーチ主構の箱断面（セル）内には施工実績の少ない設計基準強度80N/mm^2 の自己充填型高強度高耐久コンクリートを300m の長距離圧送により充填した。施工前には実物大模型にて圧送・充填試験を実施した。河川管理上の制約や広島西飛行場の空域制限等の非常に厳しい施工条件であったが，2014年３月に無事竣工し，同年３月23日に供用を開始した。