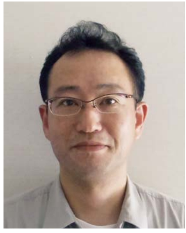
A Bridge With Ultra-High Piers Constructed Using Ultra-High Strength Materials under a Design-and-Build Contract
— Sanagawa Bridge —

デザインビルド方式を活用し高強度材料を用いた超高橋脚橋梁
— 佐奈川橋 —



* Toru YAMAMOTO, P.E.Jp: Kajima Corporation
山本　徹，技術士（建設部門）：鹿島建設（株）
** Mitsuo KAWAKAMI: Central Nippon Expressway Co., Ltd.
川上　光雄：中日本高速道路（株）名古屋支社
*** Yoshimasa NAKAI: Central Nippon Expressway Co., Ltd.
中井　義政：中日本高速道路（株）名古屋支社
**** Kazuhiro SHIBUYA: Kajima Corporation
渋谷　和弘：鹿島建設（株）
Contact: yamamtor@kajima.com
Keywords: high bridge piers, ultra-high strength concrete, climbing forms, high-altitude pumping, long-distance pumping, cantilever erection, travelling platforms, concrete placement with buckets
DOI: 10.11474/JPCI.NR.2014.85

Synopsis
The Sanagawa Bridge is located in Toyokawa City, Aichi Prefecture on the New-tomei Expressway(**Fig.1**). Super- and sub-structures were constructed in block. Various measures were taken both in design and construction, making the best use of the design-and-build contract.

Structural Data
Structure: Six-span prestressed reinforced concrete (PRC) rigid frame continuous box girder bridge
Bridge Length: Up-bound direction:636.0m, Down-bound direction: 699.0 m
Span: Up-bound direction: 81.25 + 112.50 + 105.00 + 126.00 + 123.00 + 85.75 m
Down-bound direction: 76.75 + 2x128.00 + 2x142.00 + 79.75m
Width: 10.75m
Owner: Central Nippon Expressway Co., Ltd. Nagoya
Designer: Kajima Corporation

Fig.1 Sanagawa Bridge (Over view)

Contractor: Kajima Corporation
Construction Period: Feb. 2009–Oct. 2012
Location: Aichi Prefecture, Japan

1. Introduction

The Sanagawa Bridge is located in Toyokawa City, Aichi Prefecture on the New-tomei Expressway(**Fig.2**). The order was placed under a design-and-build contract for super- and sub-structures. The given conditions and restrictions were carefully examined in the bidding phase and the bridge construction plan was developed. A six-span prestressed reinforced concrete (PRC) rigid frame continuous box girder bridge was adopted. The bridge is approximately 700 m in length and 142 m in maximum span and the bridge pier height reaches 89 m, highest throughout the New-tomei Expressway(**Fig.3**). Super RC was applied in bridge piers and ultra-high strength concrete was adopted in superstructure to ensure durability, improve the ease of construction and reduce burdens on rich environment in the vicinity. The construction work was completed in approximately three years since the commencement of work.

Fig.2 Sanagawa Bridge

2. Adoption of Super RC in bridge piers

The bridge has a total of ten piers in the up- and down-bound directions. Piers P2, P3 and P4 in either direction are 60 m or higher. Super RC was adopted in the bridge with high piers that was composed of ultra-high strength reinforcement (USD685) and ultra-high strength concrete (design strength of 50 N/mm^2) to achieve the ease of construction and seismic resistance. In this study, an experimental study was made of the effects of ultra-high strength reinforcement on shear strength. Over-arrangement of reinforcement was avoided by using ultra-high strength reinforcement (SD490) in shear reinforcing bars in addition to longitudinal reinforcing bars, in order to improve the ease of construction. As a result, the cross sections of bridge pier and of foundation were reduced by approximately 40% and 20%, respectively below the levels in conventional structures with SD345 and concrete with a design strength of 30 N/mm^2. The bridge pier was designed to have an octagonal cross section and a slit was created at midpoint on each side (**Fig.4**). Thus, aesthetical consideration was given by

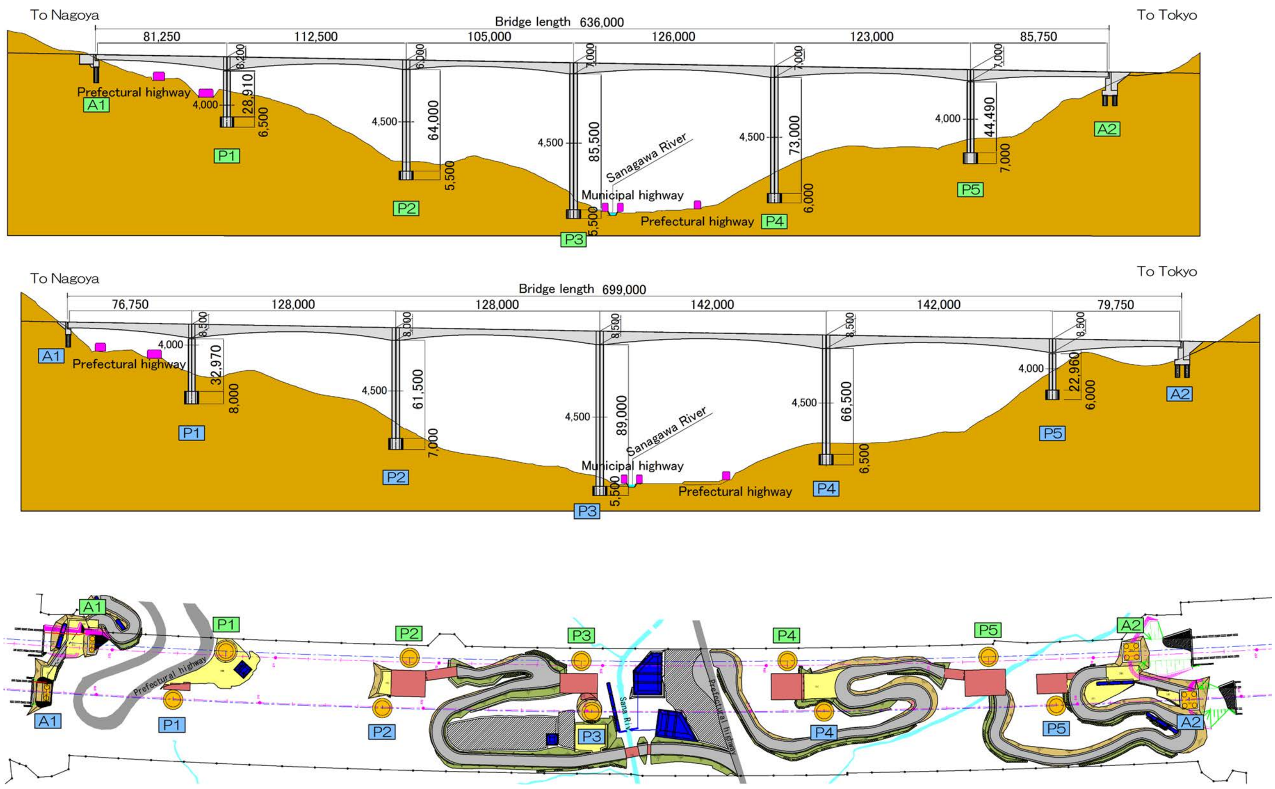


Fig.3 Elevation and plan of Sanagawa Bridge

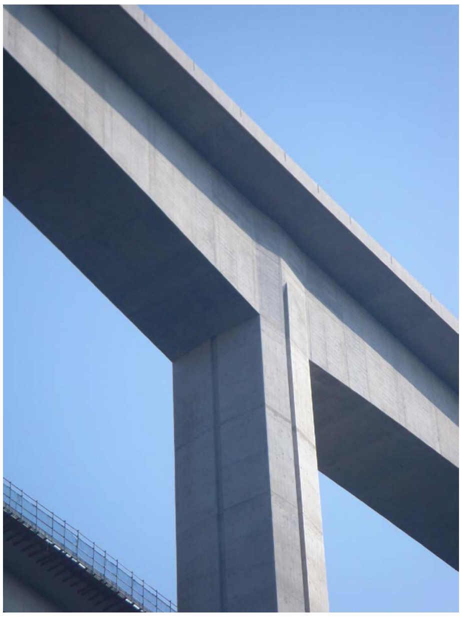


Fig.4 Overview of bridge pier and pier table

Fig.5 Construction of bridge pier (Use of climbing form and concrete placement with buckets)

applying shades and highlighting the beauty of slender high bridge piers.

3. Construction of bridge piers using climbing forms and concrete placement with buckets

The climbing form method (climbing form scaffolding support method) was adopted for Super RC bridge piers in order to ensure the safety of work at high altitudes and shorten the construction period. Then, the assembly of scaffolding at high altitudes became unnecessary. The work of hoisting was reduced because the external form rose with the scaffolding. The climbing form scaffolding was structured to work in four lifts of bridge piers and enable finishing work after the removal of the form.

For placing concrete in high bridge piers, concrete buckets were used and the age at which design strength was guaranteed was set at 91 days for the first time in Japan. As a result, the unit cement amount was reduced by approximately 40 kg/m^3 as compared with the case where ordinary pumping was adopted and the design strength was guaranteed at the age of 28 days. Thermal stress was reduced and bridge piers with fewer initial defects and higher durability were constructed (**Fig.5**).

4. Cantilever erection of superstructure using ultra-high strength concrete

A single-chamber box girder was adopted as the concrete cross section of superstructure. The objectives are to minimize the life-cycle cost and to increase work efficiency. Internal tendons in the top slab were used as prestressing steels for cantilever erection. Pre-grouted prestressing steel was used for transverse prestressing of slabs, and internally-filled epoxy resin coated prestressing strands were used as continuous external tendons. For cantilever erection, concrete with a design strength of 40 N/mm^2 that contains high-early-strength cement is generally used. In the bridge, concrete with a design strength of 50 N/mm^2 that used normal cement was adopted for the first time in Japan to reduce the possibility of occurrence of initial defects including thermal cracking. Before applying the concrete, it was verified in trial mixing that the designated strength could be secured that was required during prestressing at an age of three days (**Fig.6**).

Fig.6 Construction of superstructure

5. Consideration of natural environment

The bridge construction site is located in a village forest. Loach fish, a rare species, live in tributaries of the Sanagawa River. The local idle farmland feeds birds of prey. When developing yards, the area of land modification was minimized. The area of deforestation was minimized by securing space only for construction roads.

For constructing foundations and bridge piers on sharp slopes, a structural excavation method like cutting a bamboo was adopted in eight bridge piers (**Fig.7**). The excavation volume was reduced by more than 60% as compared with open-cut excavation by cutting the slope. A working platform was attached to each bridge pier to secure the space for working yard (**Fig.3**) to substantially reduce the area of modification of surrounding topography. Thus, environmental burdens were reduced.

Fig.7 Structural excavation like cutting a bamboo

References

[1] Kamihigashi, Y and Yamamoto,T: *Design and Construction of Sanagawa Bridge on the New-tomei Expressway -PRC box girder bridge using ultra-high strength materials*, Concrete Journal, Vol. 49, No. 7, pp. 34-40, July 2011. (in Japanese)

[2] Nagumo, H , Endoh, T , Kawakami, M , Nakai, Y , Nagao, C and Sakai, S: *Design and construction of Sanagawa Bridge (provisional name) on the New-tomei Expressway*, Bridge and Foundation Engineering, Vol. 46, No. 7, pp. 5-10, May 2012 (in Japanese)

[3] Morita, Y, Nagumo, H, Kawakami, M and Nakai, Y: *Construction of the Sanagawa Bridge on the New-tomei Expressway -Construction of prestressed concrete box girder bridge with high piers-*, Japan Prestressed Concrete Institute Journal, Vol. 54, No. 5, pp. 8-13, September 2012. (in Japanese)

Fig.8 Sanagawa Bridge (upward view)

概　要

佐奈川橋は，愛知県豊川市に位置する新東名高速道路の橋梁で，上下部工一体の設計施工一括発注方式（デザインビルド）で発注された橋梁です。採用された構造形式は，橋長約700m，最大スパン142m で，新東名路線で最大となる橋脚高89m を有する PRC6径間連続ラーメン箱桁橋です。橋脚には高強度鉄筋と高強度コンクリートを組み合せたSuper-RC 工法を適用することで，耐久性と施工性の確保を図りました。また，コンクリートの鉛直圧送に起因する初期欠陥を減少させるべく，コンクリート打設にはバケットを使用しました。上部工は，普通ポルトランドセメントを使用した設計基準強度50N/mm^{2}の高強度コンクリートを採用することで，上部工重量の低減に加え，材齢初期段階での温度応力の低減が可能となり初期欠陥の少ない上部工を実現しています。このような設計，施工上の取組みの結果，2009年10月の仮設工事の着手から約 3 年で上下部工全体を完成させました。