Sanagawa Bridge

The Sanagawa Bridge, in Toyokawa City, Aichi Prefecture, is a part of the Shin-Tomei Expressway Project. The expressway operator, Central Nippon Expressway Co., awarded a contract for the design and construction of both super and sub structures of the bridge. The successful design proposal was for a six-span prestressed reinforced concrete (PRC) rigid-frame continuous box girder bridge. The main span is 142 meters and the bridge has a total length of approximately 700 meters. The highest pier is 89 meters, making it the highest bridge between the Toyota and Gotenba junctions of the expressway.

Fig. 1 Overview of the Sanagawa Bridge

Table 1 Summary of the bridge

Name	Sanagawa Bridge
Completed	October 2012
Location	Toyokawa City, Aichi Prefecture
Maintained by	Nagoya Branch, Central Nippon Expressway Co., Ltd.
Designed and constructed by	Kajima Corporation
Design	Six-span PRC rigid-frame continuous box girder bridge
Total length [meters]	Eastbound lanes: 636.0 Westbound lanes: 699.0
Spans [meters]	Eastbound lanes: 81.25+112.50+105.00+126.00+123.00+85.75 Westbound lanes: 76.75+2x128.00+2x142.00+79.75
Carries (width)	Eastbound and westbound lanes of the Shin-Tomei Expressway (10.75m)
Work period	February 2009 to October 2012

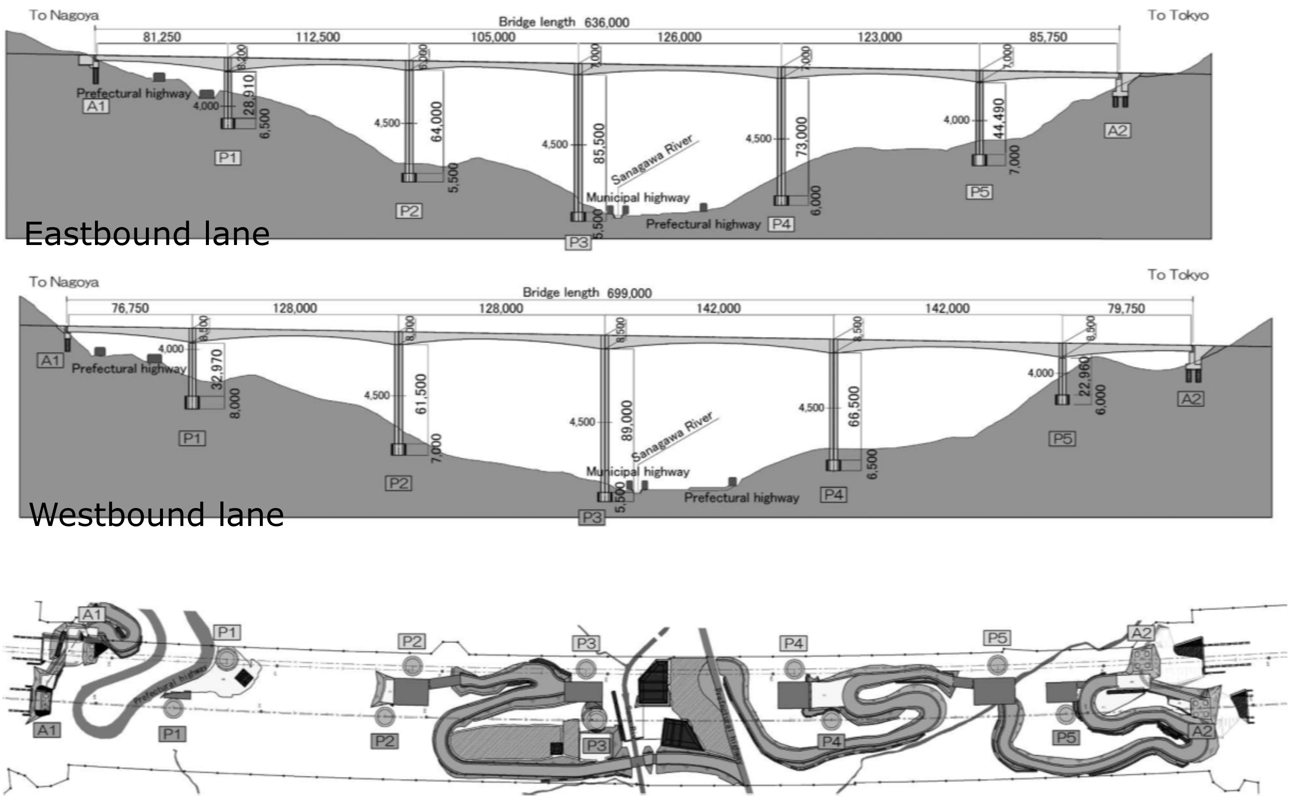

Fig. 2 Elevation and plan of the Bridge

Adoption of Super Reinforced Concrete (RC) Bridge piers

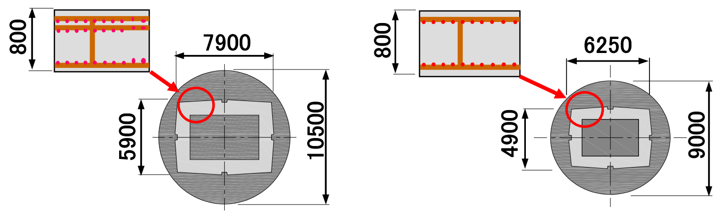

Fig. 3 Cross sections of conventional (left) and Super RC (right) structures

A total of ten piers carry the eastbound and westbound lanes, with piers 2, 3, and 4 exceeding 60 meters in height. These high piers are constructed with ultra-high-strength steel reinforcement (USD685) and high-strength concrete (with a design strength of 50 N/mm^2) to improve an assembling reinforcement work and seismic resistance. Reinforcing bar overcrowding is avoided through the use of high-strength steel (SD490) for the shear reinforcing bars in addition to the high-strength longitudinal reinforcing bars. Further, the cross sections of the bridge piers and their foundations are reduced by approximately 40% and 20%, respectively, as compared to a conventional design using SD345 and concrete with the design strength of 30 N/mm^2 (Fig.3).

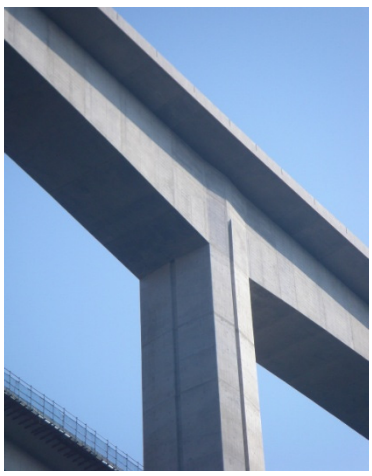

Fig. 4 The eight-faced-piers

The bridge piers are designed with an eight-faced cross section and are slotted at the midpoint on each side (Fig. 4). This aesthetic consideration gives shading to the bridge and highlights the beauty of the tall, slender piers.

Construction of bridge piers using climbing formwork and use of concrete bucket

The piers were constructed using climbing formwork (Fig. 5) so as to provide a safe working environment and dispense with the assembly of scaffolding. Hoisting was also reduced because the external forms were lifted up with the scaffolding. The climbing formwork used here was designed for continuous working on four levels: reinforcement assembly, concrete casting, curing and finishing work after form removal.

Fig. 5 Pier construction

For ease of concrete casting at high elevations, the specification was that design strength would be reached at the age of 91 days. This allowed for a reduction in the unit weight of cement of approximately 40 kg/m^3 compared to normal concrete whose design strength is guaranteed at the age of 28 days. Further, a concrete bucket was used for placement rather than a pump. Consequently, thermal stresses were reduced and the concrete was completed with fewer initial defects and higher durability.

Construction of cast-in-place concrete segmental girders

A single-chamber box girder with cast-in-place concrete segments was selected since a concrete bridge is expected to require less maintenance than the steel girder or concrete-steel composite box girder designs generally adopted for spans over 100 meters by the expressway owner. The superstructure was constructed using a form traveler system with internal tendons in the top slab. These tendons allow for balanced cantilever construction (Fig. 6). Pre-grouted tendons are used for the

Fig. 6 Segmental construction of balanced cantilever girder

prestressed slabs in the transverse direction, while cables coated with epoxy resin are used as unbonded post-tensioning external continuous tendons in the longitudinal direction.

Normal high-strength concrete (with a design strength of 50 N/mm^2) was used for the superstructure of this bridge for the first time in Japan, despite the widespread use in segmental construction of high-early-strength concrete(with a design strength of 40 N/mm^2). This reduces the occurrence of initial defects, including thermal cracking. Before casting the concrete, trial mixing was conducted in order to verify that the required strength could be achieved in three days.

Consideration of natural environment

The bridge is located in mountain area that is home to a number of rare species. The area subject to tree felling and land modification was minimized by building only essential roads, work yards and work platforms for pier construction (Fig. 2). For the construction of foundations and piers on the steep slopes, earth retaining walls shaped like diagonally cut bamboo were constructed for eight of the bridge piers (Fig. 7) to protect against landslides. This reduced the excavated volume by more than 60% compared with open-cut digging and slope cutting. Changes to the surrounding topography were substantially reduced, leading to a lower burden on the environment (Fig. 8).

Fig. 7 Cut bamboo shaped landslide-prevention wall

Fig. 8 Minimal impact on surrounding topography