Japan's Longest Seismically Isolated PC Multi-Span Continuous Bridge

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Ohito Viaduct on the Izu Jukan Expressway

Photo 1 Aerial view of Ohito Viaduct

NEED FOR IZU JUKAN (TRANS-PENINSULA) EXPRESSWAY

National highway 136 currently runs down through the Izu Peninsula from Mishima to Shimoda on its southern tip. The peninsula is one of the top tourist attractions in the country, and draws more than 60,000,000 tourists a year. Because most visit by car, the highway suffers from traffic jams in many places. The section between Mishima and Shuzenji is particularly congested during the tourist season, and it was therefore decided to construct a bypass. As part of the work, the Construction of 1,929 m-long Ohito Viaduct described here was commenced in 1992. It was completed in March 1998 at a total cost of about ¥30 billion. (Photo 1)

THE OHITO VIADUCT - INCLUDING JAPAN'S LONGEST CONTINUOUS PC VIADUCT (29 SPANS)

The Ohito Viaduct comprises five linked sections and is a multi-span viaduct with no expansion joints to enhance passenger comfort, reduce noise and vibration, and facilitate maintenance.

- No. 1 section: 7-span continuous PC viaduct with hollow floor slab, 175 m in length
- No. 2 section: 29-span continuous PC viaduct with hollow floor slab, 725 m in length
- No. 3 section: 15-span continuous PC viaduct with hollow floor slab, 375 m in length
- No. 4 section: 3-span continuous steel box girder viaduct with steel floor slab, 335 m in length
- No. 5 section: 12-span continuous PC viaduct with hollow floor slab, 319 m in length

Of these sections, No. 2 is Japan's longest continuous PC viaduct. Figure 1 shows a section through the main girder and a pier, while Photo 1 illustrates the No. 2

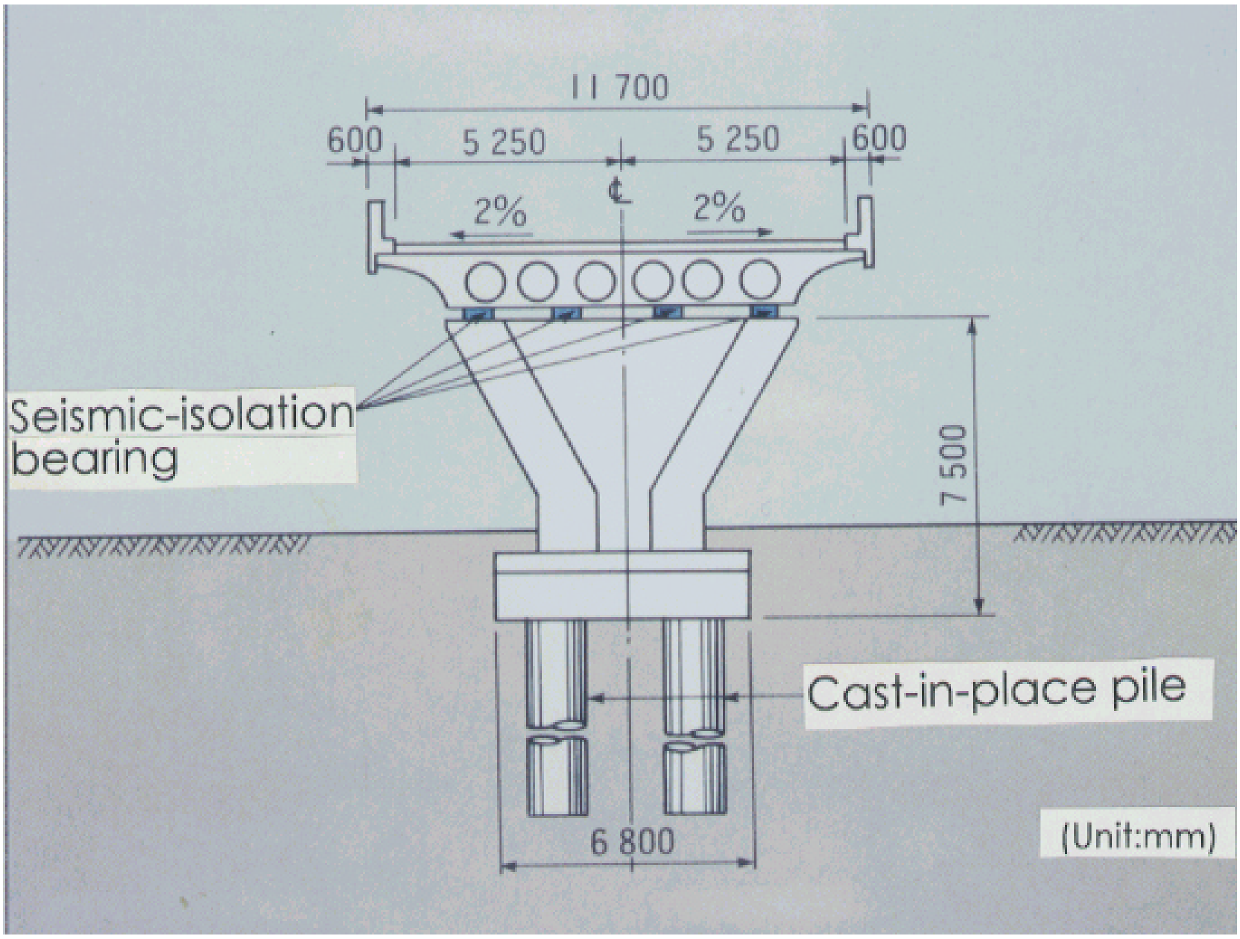

Fig. 1 Section through main girder and pier

viaduct piers. The piers are finished in decorative forms in consideration of the landscape. In the design of long structures such as the 725 m-long No. 2 viaduct, a number of problems need to be overcome. These include the expansion of girders due to variations in temperature and residual deformation resulting from contraction induced by the drying and creep characteristic of PC girders. In this case, the expansion and contraction caused by temperature variations reaches about 60 mm, and the resulting shear forces act on the substructure through the bearings between the girders and piers. The axial forces that accumulate in consequence in the PC girders have a profound effect on the required prestressing steel volume, while contraction induced by drying and creep also causes a deformation of more than 100 mm at the girder ends. The residual deformation is not expected to converge until about 5 years after completion of the girders.

ADOPTION OF SEISMIC-ISOLATION BEARINGS

Highways in Shizuoka prefecture are designated as high-specification arterial routes. Consequently, at the design stage of the exceptionally long continuous No.2 viaduct, it was necessary to incorporate measures against large deformations caused by temperature variations, contraction in drying, and prestressing stresses. At the same time, anti-seismic measures had to be taken because Shizuoka prefecture is within a special region designated by the government for enhanced disaster prevention measures because of imminent danger of the so-called Tokai Earthquake in the area. A decision was made to adopt bi-directional seismic isolation bearings, able to absorb energy both axially and laterally, to ensure safety in earthquakes. The bearings were also specified with a sliding mechanism to correct for residual deformation (post-construction strain) in the girders; deformation during and after construction was to be measured and the bearings adjusted in response using hydraulic jacks.

Of the several types of seismic-isolation bearings currently available, two were adopted for use

Photo 2　No. 2 viaduct pier

in this project: laminated rubber bearings (LRB; see Photo 3 (a)) to provide displacement-dependent absorption of seismic energy by elastic deformation, and high-damping rubber bearings (HDR; Photo 3 (b)). Figure 4 shows the load-displacement curve for an LRB under lateral seismic loading. An LRB consists of layers of laminated rubber with a lead plug press fitted into the core. The rubber functions as an isolator, reducing seismic forces by increasing the natural period of the viaduct, while the plug damps the seismic forces by absorbing mechanical energy. As compared with other types of rubber bearing, initial rigidity is higher because of the elastic resistance of the plug, while it tends to approximate that of rubber alone as displacement increases. Further, a greater damping effect is obtained because the area of the hysteresis loop is larger.

By these methods, the Ohito Viaduct was successfully completed with PC girders free of expansion joints, thus enhancing passenger comfort and ensuring safety in earthquakes. As the 21st century approaches, structural design is shifting toward an approach in which earthquake resistance is specified in terms of actual performance figures. The author feels that this viaduct is ahead of its time in that performance requirements for passenger comfort, durability, and earthquake safety have been concurrently satisfied.

Cooperation in collecting materials for this report by:

Numazu Civil Engineering Office, Shizuoka prefecture

Ohito Viaduct Construction Office, Kajima Corporation

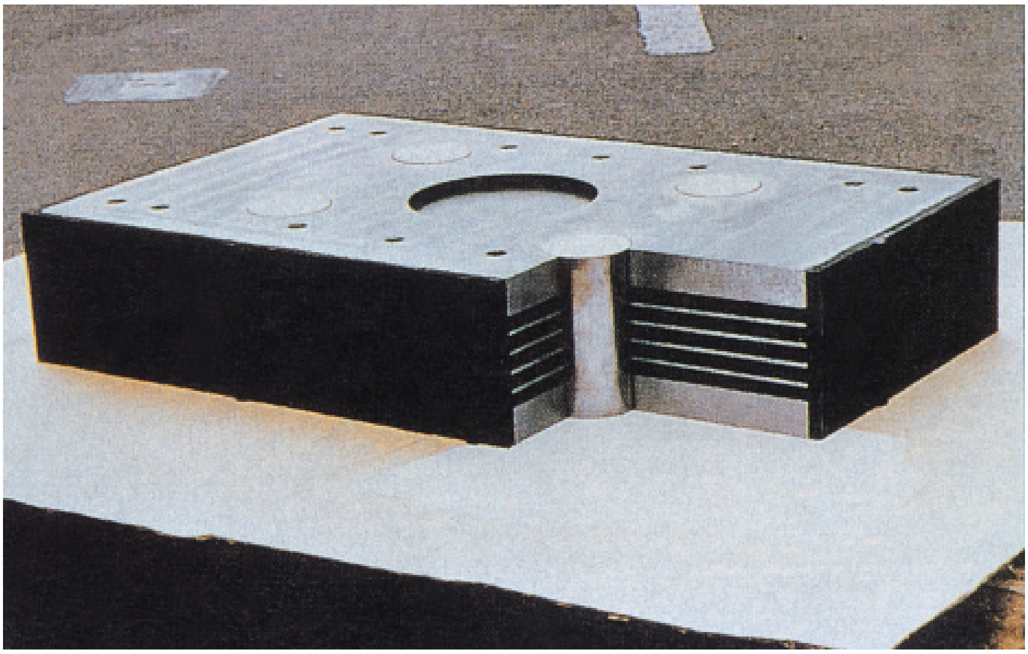

Photo 3 (a)　Laminated rubber bearing with lead plug press-fitted into core (LRB)

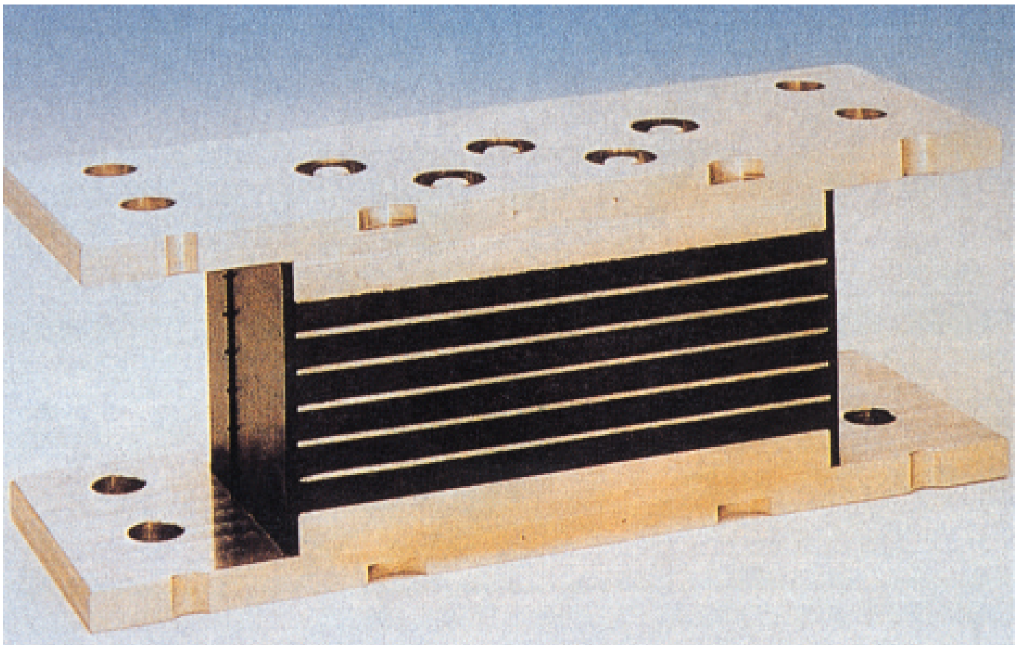

Photo 3 (b)　High-damping rubber bearing (HDR)