Renovation of the Genta Bridge: Increasing the Lane Width and Load Resistance

Introduction

Genta Bridge in Tottori prefecture is a 358-m long RC16-span continuous Gerber girder bridge spanning the Sendai River (Figure 1 and Photo 1). Constructed in 1951, the bridge has been in service for about 63 years. An increase in large vehicle traffic resulted in the bridge's having insufficient width and load resistance. However, the bridge was in good condition for its long period of operation and it was decided to renovate the bridge to extend its service life. Under the renovation project, the width was increased from 5.5 m to 6.5 m) and the load resistance was improved from T-9 load to A live load.

If the width is increased and a conventional method is used to provide reinforcement, the dead load increases considerably. This requires large-scale reinforcement of the substructure, which was precluded by constraints relating to the river, etc. Therefore, a method was adopted to renovate the bridge while easing the dead load.

This report describes the methods employed to increase the load resistance and reduce the dead load.

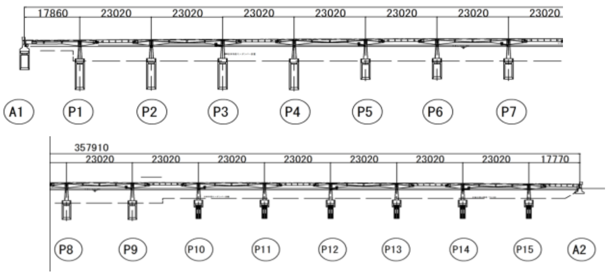

Figure 1. Profile

Photo 1. Genta Bridge before renovation

1. Overview of work

Work title:	Bridge Reinforcement Work for Genta Bridge on the Inoko-Kuniyasu Line Prefectural Road
Client:	Tottori prefectural government
Designer:	PASCO Corporation

Contractor:	Superstructure: Fuji P.S, Ube Machinery, Takanogumi Construction JV, Kyokuto, Takada, and Agatsuma JV Substructure Kuriyma Corporation, Yamakou Construction Co., Ltd.
Construction site:	Genta to Kuniyasu, Tottori City
Work period:	October 2012 to August 2014
Bridge length:	357.9 m
Width:	5.5 m → 6.5 m
Design load:	T-9 load → A live load

2. Condition of Genta Bridge

After over 60 years of operation, the bridge was aging and declining in function and load resistance. However, a preliminary investigation revealed that the concrete strengths of the bridge legs and main girders were high—25-48N/mm^2 and 36-54N/mm^2, respectively—and corrosion and cracking were minor (Photo 2). Moreover, neutralization had progressed slowly and the chloride ion concentrations were low. Hence, the bridge could be renovated rather than replaced.

Photo 2. Superstructure and substructure before renovation

3. Improvement in function and load resistance

To allow large vehicles to pass each other, the effective width was increased by 1 m, from 5.5 m to 6.5 m (Figure 2).

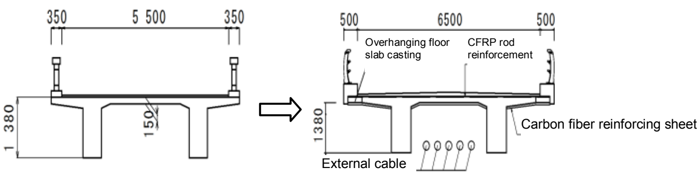

Figure 2. Sections before and after width extension

(2) Increased load resistance

The design live load of the bridge was T-9 load, which was increased to A live load in order to accommodate the increased traffic of large vehicles. To reinforce the bending strength of the main girders, five 1650 kN-type external cables were arranged in each span and prestressed (Figure 3 and Photo 3).

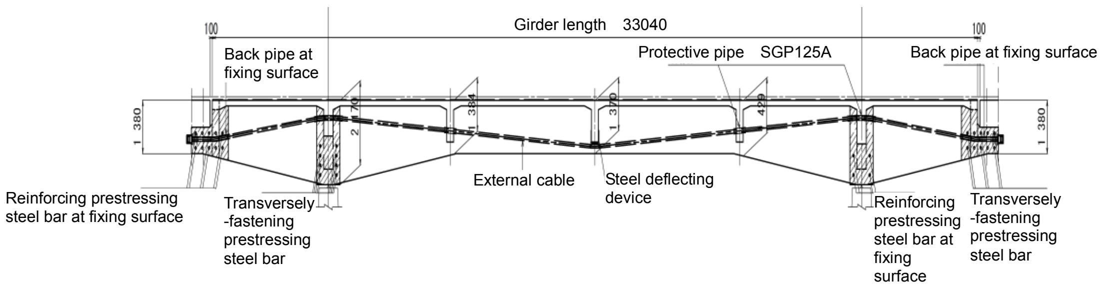

Figure 3. Reinforced section with external cables

Photo 3. Reinforced section with external cables

Shear reinforcement consisted of up to three layers of highly elastic carbon fiber sheets with unit weights of 300 g/m^2 and 650 g/m^2 that were bonded together in order to compensate for the insufficient shear capacity.

3. Reduced dead load

Concrete Gerber girders were present at a total of eight points (Figure 4). To remove the Gerber girders above the river, the pavement, ground cover, floor slab, and cross girders were removed so that the girders were completely exposed. The girders were then jacked up and transversely moved, and then transferred along the bridge surface by transfer vehicles. The Gerber girders were replaced (Photo 4) with steel girders (Photo 5 and Figure 5). This eliminated about 42 kNm of the dead load.

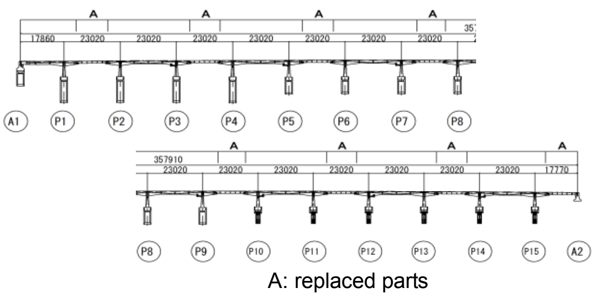

Figure 4. Positions of replaced parts

Photo 4. Removal of Gerber girders

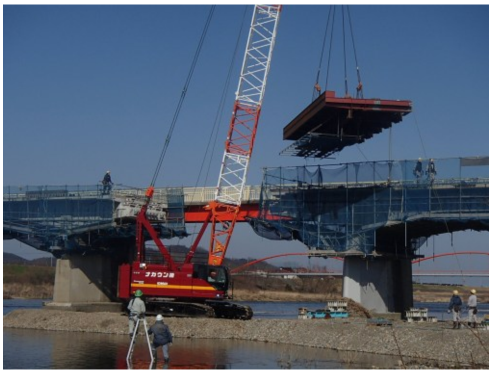

Photo 5. Installation of steel girders

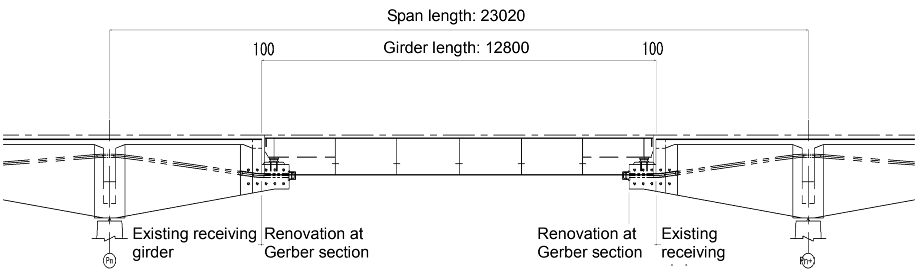

Figure 5. Replacement section (steel girder)

(2) Reinforcement of floor slab

The floor slab was reinforced in order to compensate for insufficient bending strength and shear capacity resulting from the greater width and increased wheel load of the floor slab.

Reinforcement methods that produce only a small increase in the dead load were compared. For reasons of constructability and economy, the CFRP (Carbon Fiber Reinforced Plastic) rod method was employed to reinforce the upper surface of the floor slab (Photo 6). This method resulted in a greater decrease in the weight by 12 kN/m than would have been possible with general additional floor slab casting methods.

Photo 6. Reinforcement of upper surface of floor slab

4. Reducing the dead load

The dead load was reduced by applying several measures to the bridge surface, including the use of lightweight aluminum railings. Figure 6 shows the difference in the dead load before and after the renovation. The dead load per bridge leg was 2329 kN before the renovation. After the renovation, it was 2340kN, showing that the dead load increased only by about 0.5%. This method reduced the dead load by about 40% more than the continuous work method used in similar renovation works.

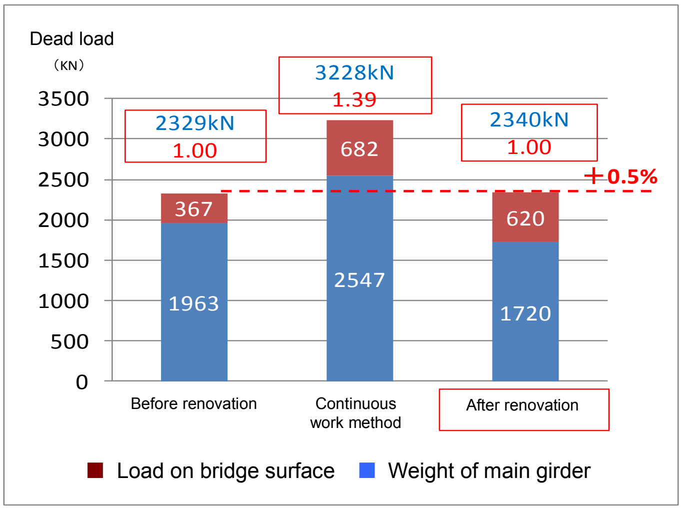

Figure 6. Difference in dead load

5. Improving seismic resistance

Figure 7 is a flow chart of the study of the bridge's seismic resistance. The bridge legs had nearly the same shape and volume of steel reinforcement, but the movable legs contained sections in which the reinforcement volume had been changed while the fixed legs did not. While the dead load after extending the width was limited to the level before renovation, the study showed that the movable legs satisfied the Level 1 seismic ground motion specification but the fixed legs did not. Neither the movable legs nor the fixed legs satisfied the Level 2 seismic ground motion specification.

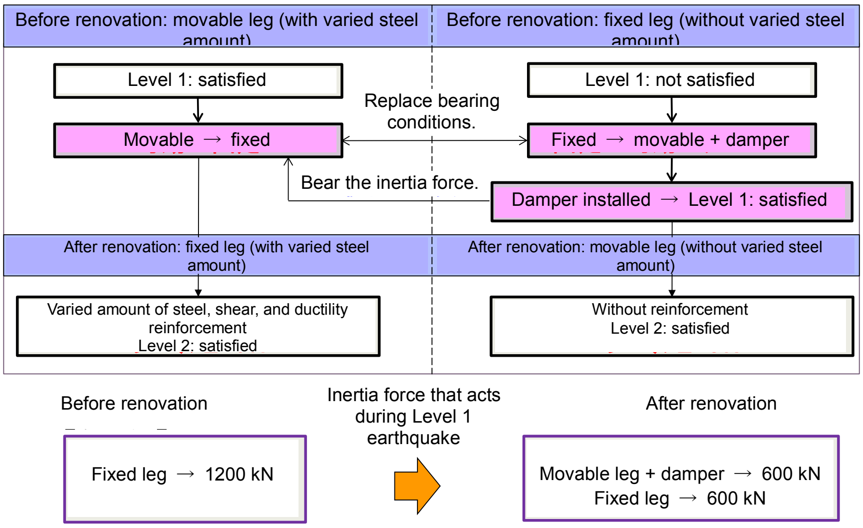

Figure 7. Study flow of seismic resistance

To increase the seismic resistance, a polymer cement mortar spray method that blocked less of the river's cross-sectional area after reinforcement. The bearing conditions were changed by replacing the movable legs with fixed legs and the fixed legs with movable legs. Moreover, dampers were installed on the replaced movable legs (Photo 7) in order to bear the inertia force. The dampers increased the inertia force for the movable legs (fixed legs after renovation) but decreased that of the fixed legs (movable legs after renovation). Increasing the steel volume, shear, and ductility, satisfied the seismic resistance requirement and limited the load imposed on the foundation.

Photo 7. Installation of damper

6. Conclusion

In this project, a company specialized in prestressing, a steel bridge manufacturer, and a local general contractor formed a joint venture for the superstructure work. The parties with different specialties formed a team to deal with various types of construction.

As they are suitable as long bridges, numerous reinforced concrete Gerber girder bridges were constructed before and after the War. Some of them are still in good condition, as this bridge was.

In Japan, which faces a declining birth rate and aging population, as well as rapidly deteriorating social infrastructure, we would be pleased if this project serves as a guide for infrastructure management utilizing existing infrastructures.

Photo 8. Renovated Genta Bridge

References:

1) Tsutomu Kajiwara, Hiroshi Tanaka, Shinichi Mihara, and Hiroshi Maeda. "Construction of Genta Bridge Reinforcement." *Prestressed Concrete,* Volume 56, No. 4, pp. 48-53, June 2014

2) Takuhiro Kimura, Hiroshi Ukita, Tsutomu Kajiwara, and Mitsuhiro Suzuki##. "Renovation of Genta Bridge with Reduced Dead Load." *Doboku Seko,* Vol. 56, No. 7, pp. 86-89, July 2015