Structural Improvement of Existing Steel Bridges by Combining the Steel Girders with Concrete Decks

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More than half of the steel railway bridges in Japan have been in service beyond their designed lifetime. Some of them need to be replaced mainly because corrosion has caused degradation of their load-carrying capacity. However, replacement is an expensive option which is also costly in terms of time as train operations have to be halted.

As one method of improving the load-carrying capacity of the bridges without replacing them, we proposed the idea of combining the steel girders with a concrete deck, as shown in Fig.1. This method changes the structural system of a steel girder into a composite girder and increases its load-carrying capacity. In addition, this method also helps to mitigate the accumulation of fatigue damage by reducing stress in the girders and to reduce noise caused by vibration of the bridge members.

To implement this technology, an increase of the dead load and the method of deck installation needed to be examined. Focusing on the dead load, the range of application for this method was estimated. As for the deck installation, the key points would be the time required for installation and connection between the girders and the decks. Then we proposed a method requiring only a short time for installation using precast-concrete decks and we evaluated the resistance of the girder-deck connection by means of loading tests.

When the concrete deck is installed on the existing bridge, an increased dead load acts directly on the bridge supports. Then we calculated the bearing stress of the concrete of the supports, before and after the deck was installed. The calculation models are deck girders and through girders with a simple span and a single track. Figure 2 shows the results of the calculation. In the bridges with span widths of more than 40 m, the bearing stress of the concrete of the supports exceeds the allowable stress. Thus, we found that this method could be applied to bridges with span widths of less than 40 m.

When installing concrete decks on steel girders, we had to consider the time constraint. On lines with heavy traffic, halting train operations is not acceptable and the installation has to be finished within a specified time slot during the night work. So we proposed a method of installation using a precast-concrete deck. In this method, decks can be installed during a short-time possession at a worksite. Furthermore, installing precast concrete decks on longer bridges can be carried out by splitting the workload into several short night-time possessions for each precast deck (Fig. 3).

Focusing on the installation method with precast concrete decks, it is necessary to examine the resistance of the connection between the girders and the decks. For this reason, we proposed a connection system of steel girders and precast-concrete deck using steel fasteners and mortar filler (Fig.4). The strength of the connections was then evaluated by loading tests. Figure 5 shows the loading test of the connection by filler mortar. As a result, it was found that the connection has high shear resistance because of rivet heads on the surface of the steel girders (Table 1). Loading tests of the connection using fasteners were also carried out, and it was found that the connection has sufficient resistance against vertical and transverse forces.

In this study, a method of structural improvement of existing railway steel bridges by combining the steel girders with concrete decks was proposed. Then the applicability of the method was evaluated through design calculations and loading tests. We found that the deck installation method using precast concrete decks can be used with short-time possessions during the night work and that the girder-deck connection has sufficient strength to withstand the forces applied by live loads. We are planning to develop this technology so that it can be applied to actual structures.

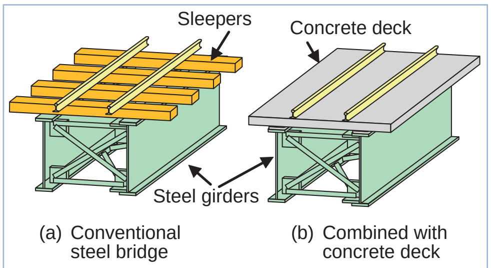

Fig. 1 Combining the steel girders with a concrete deck

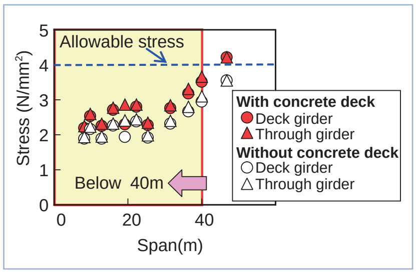

Fig. 2 Bearing stress at support concrete

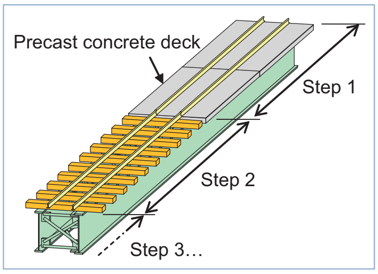

Fig. 3 Installation method with precast concrete decks

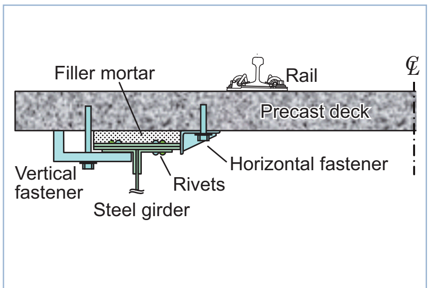

Fig. 4 Girder-deck connection

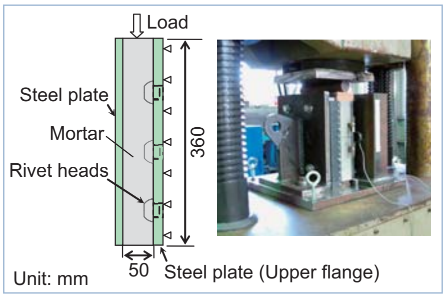

Fig. 5 Shear loading test

Table 1 Results of shear loading test

Type	Rivet heads	Treatment of upper flange	Strength (kN)	Strength per rivet head (kN)
A	6 heads	None	109.1	18.18
B	6 heads	Blasted	141.0	23.50
C	None	None	0.567	—