Rehabilitation of Wakamiya railway bridge (Japan)

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4. Rehabilitation of Wakamiya Railway Bridge (Japan)

Owner: *Central Japan Railway Company*
Engineer: *Central Japan Railway Company Railway Technical Research Institute*
Work's duration: *3 months*
Service date: *March of 1972 for up-bound line*

The article describes the rehabilitation of a railway concrete slab girder bridge with double reinforcement by rigid concrete frame.

Introduction

Tokaido Shinkansen line is a representative railway line in Japan where the trains are operated at a maximum speed of 220 km/h. Since the beginning of the service in 1964 more than 2 billion passengers have been transported on this line.

All along the track, many types of concrete bridges have been constructed to overpass or underpass roads etc. Concrete slab girder bridges with double reinforcement, which is profitable to decrease the depth of the girder, were planned to cross roads etc. with a span ranging from 7 to 15 meters. About 370 slab girder bridges of this type, were constructed. The stress and deflection of the bridges under the action of train load are larger than those of reinforced concrete of other types, because both the depth and the rigidity of slab girders are smaller than those of concrete bridges of other types.

After about 4 years from the beginning of the service, a considerable increase in deflection of the bridges was measured and many cracks appeared on the bottom surface of the bridges. After checking these bridges several considerably damaged bridges were reinforced by increasing the rigidity.

Situation prior to rehabilitation

The Wakamiya bridge (Fig. 1). located at 439 km from Tokyo, was damaged as follows:

1) The bridge deflected vertically from 3.5 mm to 4.7 mm at the center of the span under a test train load. The ratios of deflection to span length are 1:2,860 and 1:2,130 respectively. These ratios are nearly equal to the specified value.

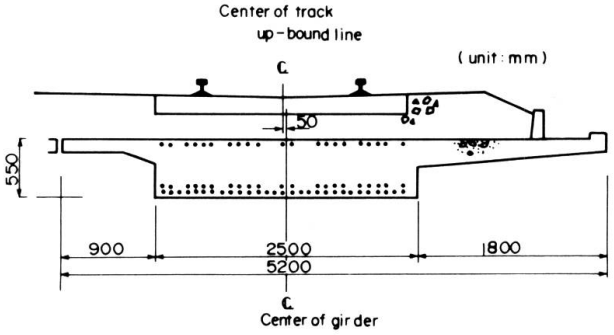

Fig. 1 Section of the girder of Wakamiya Bridge

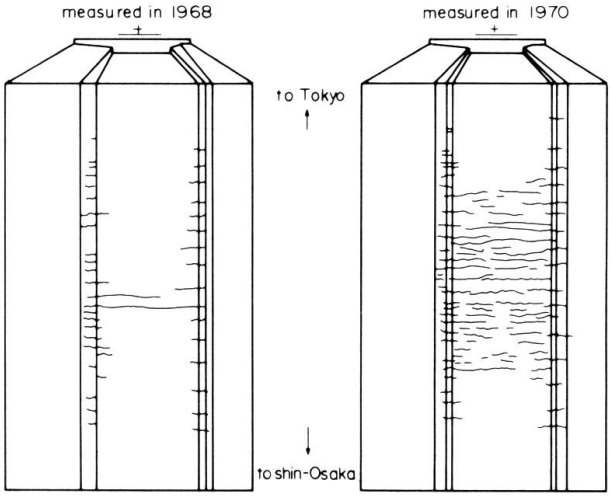

Fig. 2 Crack distribution on the concrete surface of a girder of up-boundline

2) The maximum width of cracks on the surface of the concrete grew to 0.2 mm but most of them were 0.1 mm wide. Cracks opened on average by 0.04 mm under train load and returned by 0.01 mm.
3) The crack distributions on the concrete surface in June 1968 and in October 1970 are shown in Fig. 2. The number of cracks under repeated loading increased in about two years.
4) The ratios of the measured stress and deflection under test train loading are shown in Fig. 3. where the deflection ratio is the value of the deflection at the center of the span at each speed of test train to the value of the deflection at the speed of 158 km/h. The maximum increasing ratio amounts to 1.7, while the specified value is 1.43.

Cause of damage and measures adopted

The cause of damage seems that the frequency of the bridge vibration under repeated train loading approached the natural frequency of the bridge and that the resonance of the bridge was induced. The resonance seemed to have increased the deflection and to have caused many cracks.

The countermeasure to this damage is to avoid the resonance of the bridge. This is attained by setting the parameter v/2fl equal to less than 1/3, where v: train speed, f: natural frequency of the bridge and l: span length. As the natural frequency increases according to the increase of the cross section of the bridge, it is possible to avoid the resonance. In the case of Wakamiya bridge, the slab girder was strengthened by a concrete rigid frame. The general view of reinforced Wakamiya bridge is shown in Fig. 4.

As the result of this reinforcement, the deflection was reduced to half of the original bridge. On Tokaido Shinkansen line, 8 girders of 4 bridges were improved by the same rehabilitation method.

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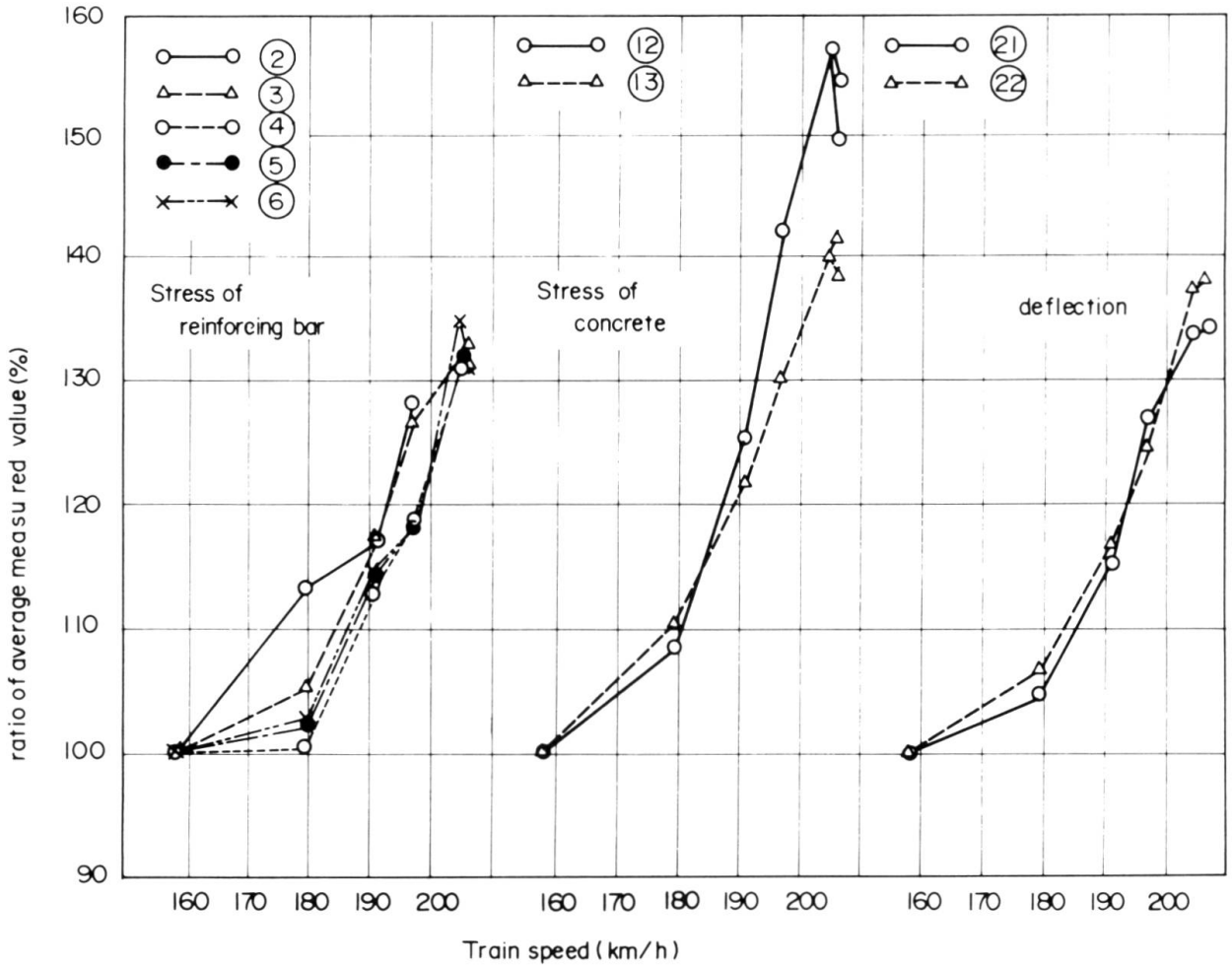

Fig. 3 Relationship between ratio of average measured value and train speed

(unit: mm)

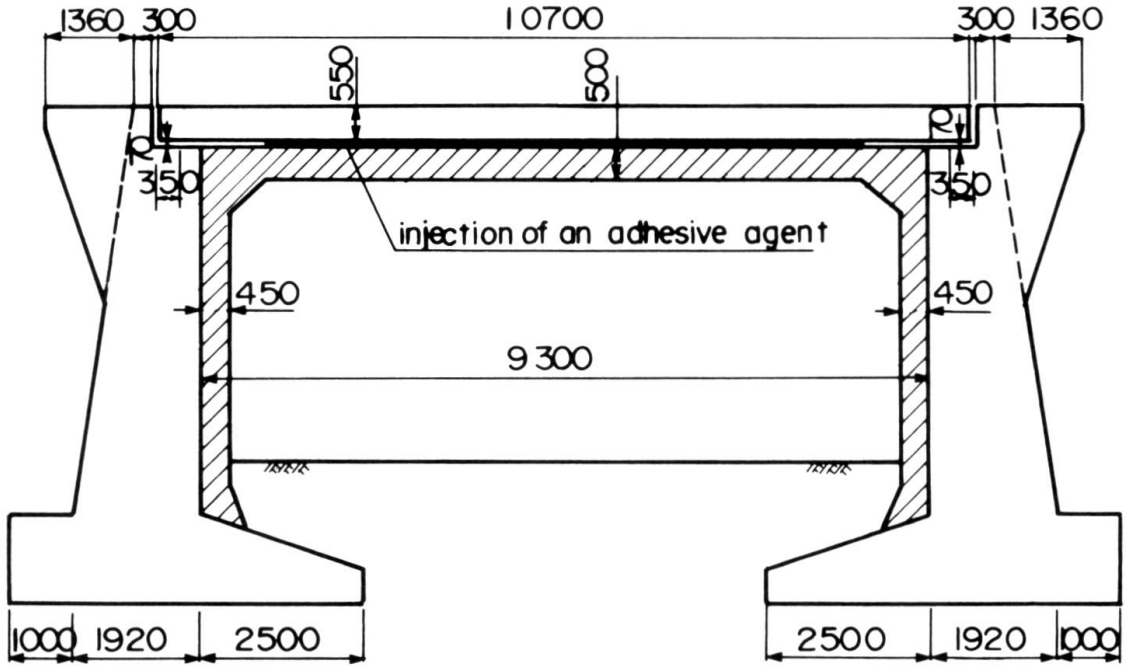

Fig. 4 General view of reinforced Wakamiya Bridge