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12. Countermeasures against Noise and Ground Vibration

Since the Tokaido Shinkansen was opened, the noise and ground vibration due to train passage has proven a nuisance to the residents along the line. An improvement in the steel bridges of open floor without ballast was urgently required, because these generated greater noise than others.

The government issued the recommendation of permissible traffic noise levels a few years ago. The following are outlines of the methods for improvement of bridges in use, new types of steel bridges in which noise is well controlled and the methods for abatement of ground vibration.

Improvement in Open Floor Steel Bridges in the Tokaido Line

In order to satisfy the recommendation that noise level be limited as far as possible, various experiments and investigations were conducted. Finally, covering the bridge was found to be practically the best method and was thus applied to all the open floor steel bridges in the Tokaido Line located in residential areas, about 100 in number and 11 km in total length. The construction had to be carried out while the bridges were in use for train operation.

Fig. 1 shows an example of noise control construction of an open floor steel bridge of deck type. The frames which support the cover plates are attached to the bridge members via rubber cushions. Moreover, the cover plates themselves are composed of three layers (two steel sheets and a sheet of special synthetic material in between) to damp the vibration even if it is transmitted to the cover plates. As a result, noise reduction of as much as 25 dB (A) was achieved directly under the bridge as illustrated in Fig. 2. The effect of rubber cushions on vibration of cover-plates is illustrated in Fig. 3.

In case the noise cannot be sufficiently controlled down to the recommended noise level, removal of houses or improvement of windows have been executed.

Development of New Structures, Taking Noise Reduction into Account

Whilst open floor steel bridges were constructed in the Tokaido Shinkansen, the first of the "new lines", they were dispensed with in the later shinkansens. Concrete structures are applied as much as possible, because they are inherently low noise structures. But in special cases such as construction on weak ground, erection across a wide river and passing over railways, steel structures must inevitably be used, but here devices are, however, added to reduce the noise down to as low as that of ordinary concrete bridges. In bridges located in the ballast track sections, 25 mm-thick rubber mats are always laid under the ballast, presenting a remarkable effect (more than 10 dB (A) reduction under the bridge).

Steel-concrete composite girder bridges are preferably used, but where it is applied in the slab track section without ballast, blocks of damping material composed of rubber and asphalt are attached to the surface of the web plates and concrete is placed on the lower flange plate for damping their vibration as shown in Fig. 4. In the case of truss bridges constructed in the slab track section, the floor system is encased in concrete as shown in Fig. 5 of chapter 3.

A truss is usually made of steel, but after extensive theoretical and experimental investigation a prestressed concrete truss bridge was constructed in Hiroshima, on the Sanyo Shinkansen, thus combining noise control and economy (see Photo 3).

Other Methods for Reduction of Noise

In the Tohoku Line, which is now under construction, a special section as long as 30 km has already been opened in order to carry out various tests on new types of rolling stocks, tracks and structures. There also, noise abatement and reduction of ground vibration figure among important objectives. Various shapes of side walls are tested, and sound-absorbing materials are used as a subsidiary method.

Methods for Reduction of Ground Vibration

Ground vibration depends greatly on the condition of the ground on which structures are constructed. It is essentially difficult to change it greatly by structural treatment. It is, however, known that if the bridge is long, the ground vibration is smaller and that concrete bridges of hollow slab type generate less vibration than ordinary rigid frame type concrete viaducts.

Generally speaking, steel bridges are desirable from this point of view. Insulation walls in the ground are tested also to see if they are effective in reducing vibration in the ground.

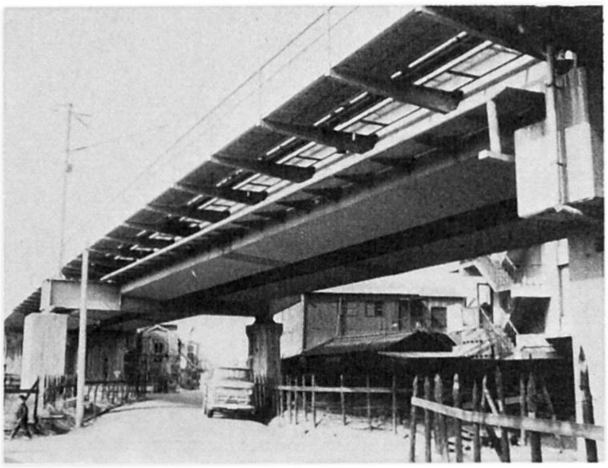

Photo 1 Bridge before improvement

Photo 2 Bridge after improvement

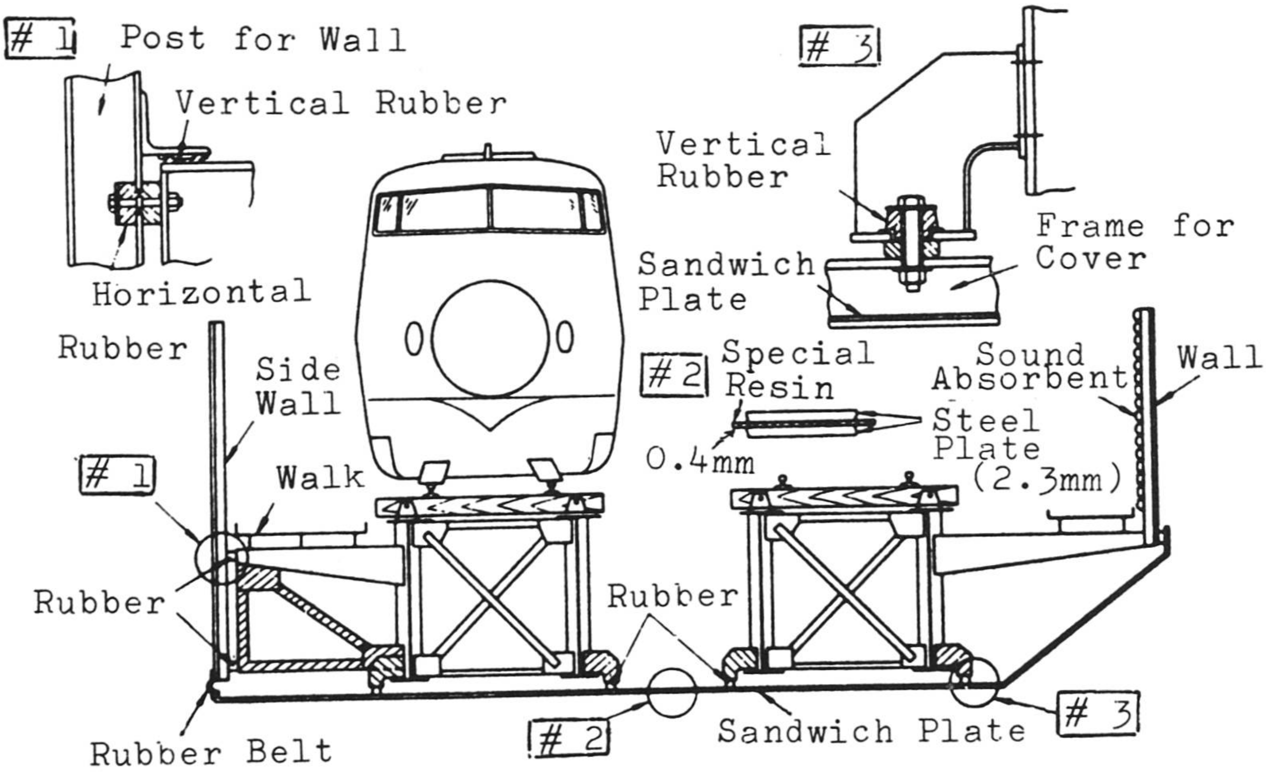

Fig. 1 Noise-control device for a long open floor steel bridge

Photo 3 Prestressed concrete truss bridge

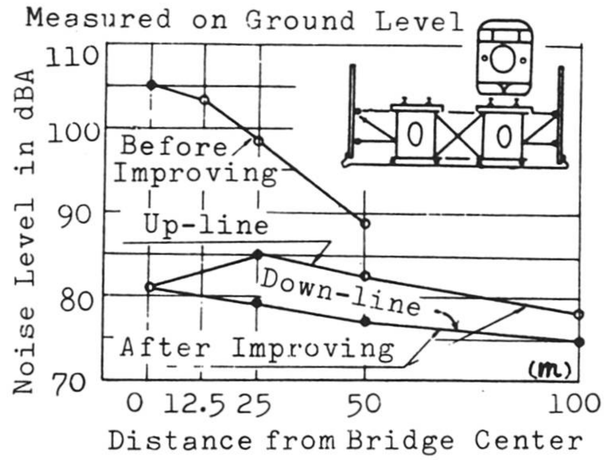

Fig. 2 Relation between noise-level and distance from bridge

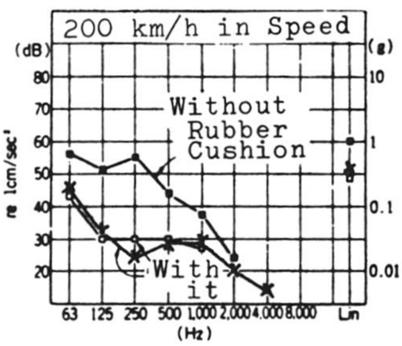

Fig. 3 Effect of rubber caushions on vibration of cover-plates

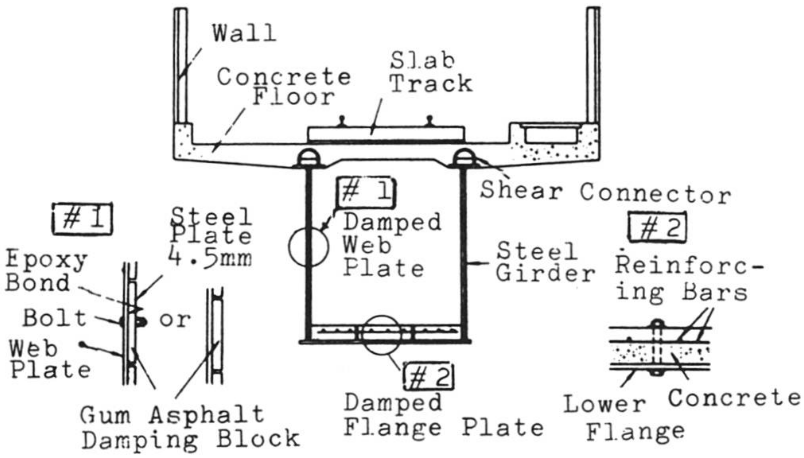

Fig. 4 Noise-control device for a composite bridge