Development of a Silent Steel Railway Bridge

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A number of steel railway bridges have been constructed in Japan.

The advantages of steel railway bridges are: the feasibility of a long span structure due to the high-tension strength of the steel, the ease of on-site construction, and the ease of quality control that comes with factory manufacturing. On the other hand, it has been pointed out that steel railway bridges generate a large amount of structure-borne noise since the bridge members have thin plate structures that are likely to vibrate. Therefore, depending on the circumstances, the construction of steel railway bridges in urban areas tends to be avoided. In developing measures to limit or prevent structure-borne noise, RTRI focused on improving the performance of insulation to reduce the vibration generated by trains running across the bridge, and then developed a new type of steel railway bridge where the track and the reinforced concrete (RC) deck are elastically supported by resilient materials.

1. Outline design of a silent steel railway bridge

Figure 1 shows the outline design of a silent steel railway bridge. We adopted floating ladder track which offers excellent performance in terms of reducing vibration, and the RC deck is supported by resilient materials. The floating ladder track has a load distribution effect due to the high bending rigidity of the ladder sleepers in the longitudinal direction and a load transfer reduction effect thanks to a low supporting coefficient of the track. The floating RC deck constitutes a heavy mass spring system which supports the RC deck by means of resilient materials, and the deck reduces the effects of acceleration forces being transferred to the structure mainly in the range of frequencies below 100Hz.

These structures improve the insulation performance against the vibration generated by trains running over the bridge and they can also reduce the vibration of each member of the steel railway bridge which becomes a source of structure-borne noise.

Further, we are assuming that this type of bridge would be constructed in urban areas where there are strict limitations on structure-borne noise. In Japan, the type of bridge constructed in urban areas tends to be a through bridge on which the track is carried by the lower horizontal members of the structure. Therefore, the floating bridge is a type of through bridge. As floating ladder track has been adopted for the track structure, the level of the rails can be kept low, so permitting this type of bridge to be used even where there are severe restrictions on the space available such as below girders in urban areas.

2. Vibration reduction effects of a silent steel railway bridge

Figure 2 shows the full-scale model bridge installed on the test track inside the premises of RTRI. We demonstrated in quantitative terms how effective a steel railway bridge is in reducing structure-borne noise. We did this by performing impact experiments and train-running experiments. In order to check the structure-borne noise reduction effect for the steel railway bridge, the impulse vibration experiment and train-running experiment were conducted using different supporting conditions for the ladder sleeper and the RC deck.

Figure 3 shows an example of the results of the experiments. We can see that compared with the vibration velocity level of the main girder web of a rigid support structure, that of the silent steel railway bridge is reduced by 10.1dB(A) at a train speed of 40 km/h. Moreover, we can see that compared with the accelerance of the main girder web of the rigid support structure, that of the silent steel railway bridge is reduced by around 50Hz.

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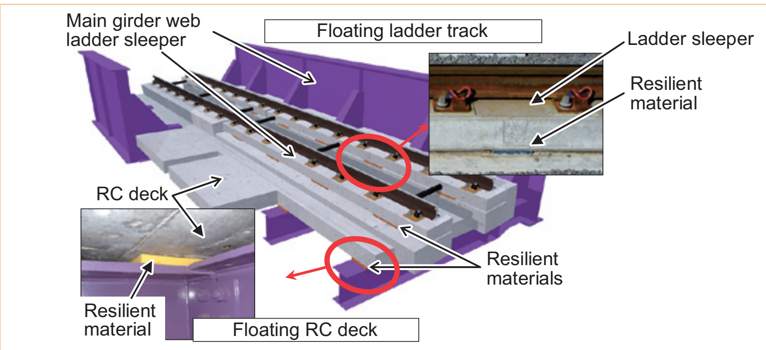
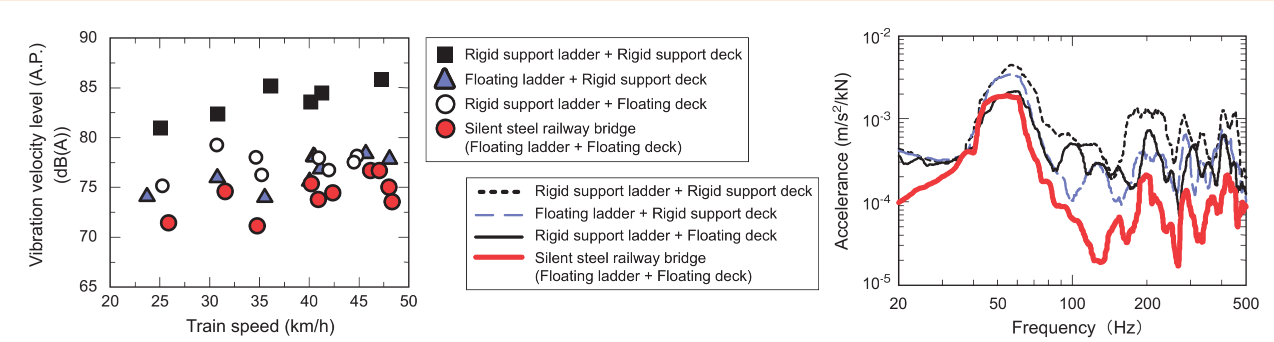


Fig.1 Outline of the silent steel railway bridge

Fig.2 Full-scale model bridge



(a) Vibration velocity level of the main girder web with a train speed of 40 km/h

(b) Accelerance of the main girder web

Fig.3 An example of results from the experiments