Reduction of Carbody Flexural Vibration of High Speed Train through High-damping Elastic Support of Under-floor Equipment

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1. Introduction

Reduction of flexural vibrations will improve the ride quality of a railway vehicle. RTRI has studied a method to reduce multi-modal flexural vibration and has now developed a high-damping elastic support to the under-floor equipment that reduces the flexural vibration of the carbody. This report describes the vibration measurement test results which verify the vibration reduction performance of the elastic support which is applied to the high speed train (Shinkansen type test vehicle).

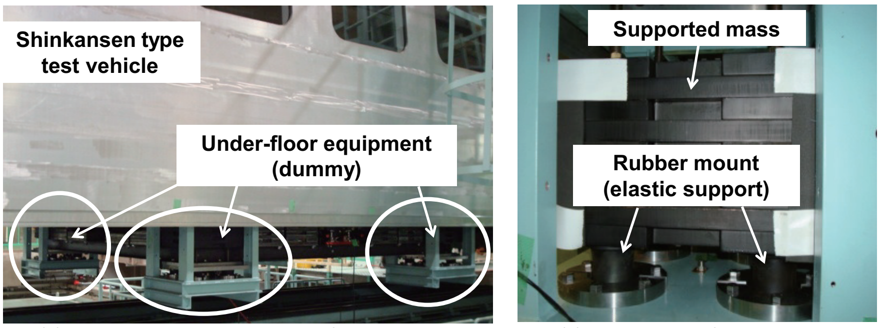
2. High-damping elastic support for underfloor equipment

Our method uses a dynamic vibration absorber that utilizes the under-floor equipment as a mass element and: (1) has no need for cumbersome procedures to adjust the natural frequency or damping characteristics, and (2) has a multi-mode vibration reduction effect.

Figure 1 shows how the dummy underfloor equipment was attached to the carbody and supported elastically by simple rubber mounts for the excitation tests. In one Shinkansen train set, most underfloor equipments of several hundreds of kilograms are attached discretely but some vehicles have traction transformers or main traction converters of several tons in the center of the underfloor. In consideration of this situation, following two types of underfloor equipments arrangements (Fig.2) were used for the excitation tests: (a) distributed mass with a set of four dummy under-floor equipment assemblies (about 245 kg/assembly), and (b) one concentrated mass of 3380 kg. Each rubber mount was designed so that the dummy under-floor equipment had a natural frequency somewhat lower than the target frequency. To exert the high-damping properties, the rubber mount was made of butyl rubber.

3. Result of excitation tests

The excitation tests were carried out at the RTRI rolling stock testing plant for the two loading conditions. Both configurations were tested with rigid and elastic (rubber) support mounts. Figure 3 shows the acceleration power spectrum densities (PSDs) on the floor area closest to the central window of the carbody for each loading configuration. (The simulated running excitation corresponds to 240 km/h). The PSDs show large peaks corresponding to two flexural vibration modes at 9 Hz and 11 Hz when the rigid support was used. Both peaks were reduced by the high-damping elastic support and therefore the multi-modal vibration reduction effect was clearly confirmed under both loading conditions (distributed and concentrated mass).



(a) Test vehicle with dummy under-floor equipment (b) Dummy under-floor equipment

Fig.1 Setting of the dummy under-floor equipment to the carbody

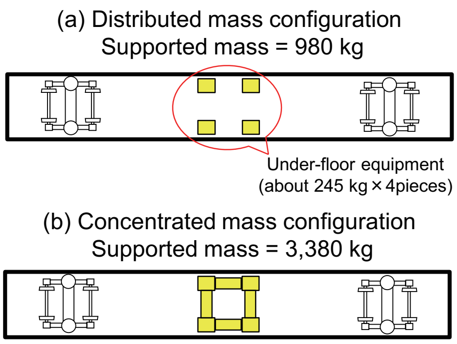
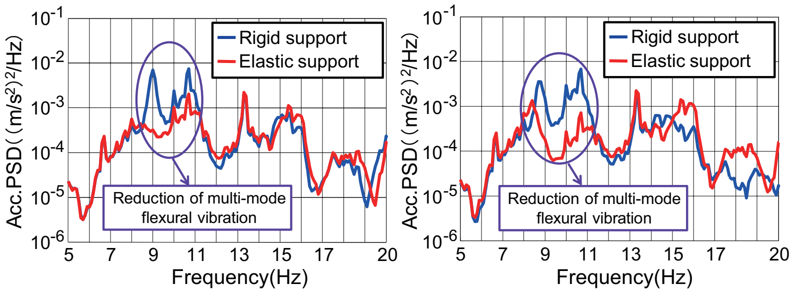


Fig.2 Loading conditions of the under-floor equipment



(a) Distributed mass (980kg) (b) Concentrated mass (3,380kg)

Fig.3 Acceleration PSD on the carbody floor measured under the central window
(Simulated running excitation corresponding to 240 km/h)