Reduction of Car Body Elastic Vibration Using High-Damping Elastic Supports for Under-Floor Equipment

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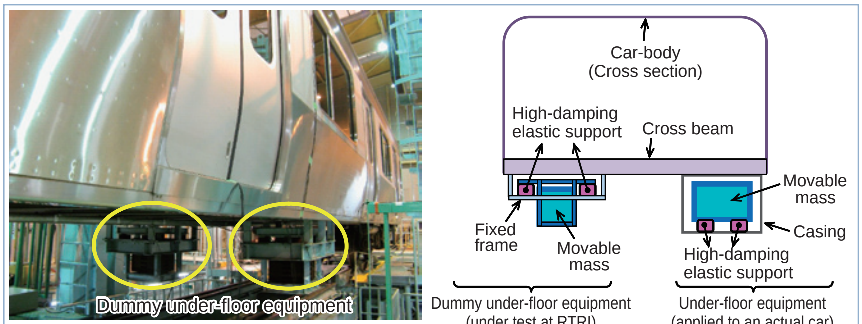
Reduction of car body elastic vibration has become more important than ever in order to maintain and improve the present level of ride comfort, particularly given today's higher operating speeds and lighter weight railway vehicles. The Railway Technical Research Institute (RTRI) has been studying methods to reduce car body elastic vibration and has now developed a high-damping elastic support for under-floor equipment that reduces the elastic vibration of the car body. By supporting under-floor equipment elastically with high-damping members, not only is the car body elastic vibration reduced but also propagation of the vibration generated by the under-floor equipment is suppressed. It is quite simple to apply this technique to rail cars, as it requires only nominal changes to the supports for existing under-floor equipment while adding only a small amount of mass to the car body.

This high-damping elastic support for equipment is designed to have a similar effect as passengers by reducing car body elastic vibration. It is normally thought that passengers are equivalent to an increase in the mass of car body and work to reduce its natural frequency. In contrast to this generally accepted view, the author and co-researchers have clarified that passengers (1) do not change the car body natural frequency significantly, which means that passengers exert an effect different from that of increased car body mass and (2) substantially reduce car body elastic vibration.

As already known, the human body has two specific vibration characteristics; a comparatively low natural frequency, 5 to 6 Hz, and high damping performance. In the course of this study, the researchers also clarified that these vibration characteristics work to reduce car body elastic vibration. They also demonstrated that car body vibration can be reduced in a wide frequency range without cumbersome work to adjust for natural frequency or damping ratio required for normal dynamic vibration absorbers when passengers are aboard. These findings suggest that a new effective damping device can be developed to suppress car body vibration, if these human characteristics can be simulated appropriately.

Thus, using materials featuring higher damping than that of the car body, RTRI manufactured prototype high-damping elastic supports to set the natural frequency of the under-floor equipment suspension system lower than that of car body. In order to test the prototypes, RTRI installed two sets of dummy under-floor equipment which are suspended using the high-damping elastic supports (one having an electro-dynamic exciter to simulate vibration generation of the under-floor equipment, and the other being just deadweight) on a test car equivalent to those used for commuter transport, as shown in Fig. 1. The hanging support structures are similar to the hydraulic mounts used for automobiles and construction machines. The high-damping elastic supports were subjected to excitation tests at RTRI's rolling stock testing plant. The tests confirmed the validity of the high-damping elastic support. As shown in Fig.2, the new supports reduce multiple modes of car body elastic vibration simultaneously and insulate the vibration from equipment. The vibration of the under-floor equipment remains substantially unchanged or rather reduced (see Fig.3).

The high-damping elastic support for equipment can be implemented on various cars as it features a lightweight structure, there is no need for specific maintenance and it is a convenient method to reduce car body elastic vibration.



(a) A test vehicle with dummy under-floor equipment

(b) Application of the high-damping elastic support

Fig. 1 Test vehicle under excitation test at RTRI's rolling stock testing plant and a schematic illustration of the application of high-damping elastic supports

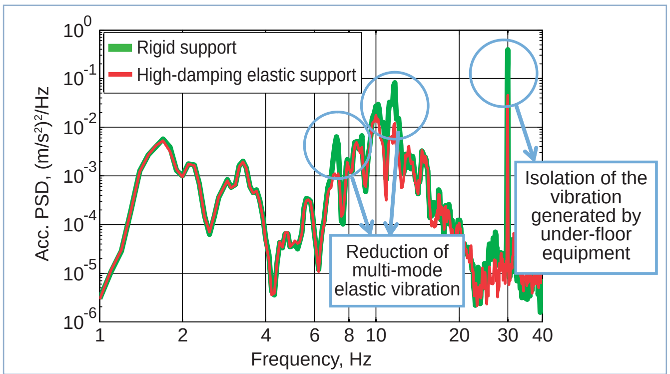


Fig. 2 Acceleration PSD on the car-body floor (measured under the central window)

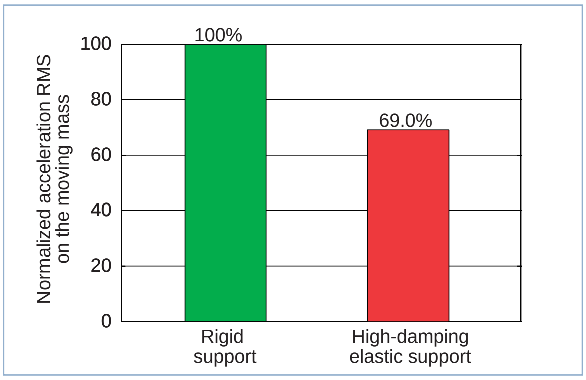


Fig. 3 Acceleration RMS of the mass of a dummy equipment (normalized with the case of rigid support taken as 100%)