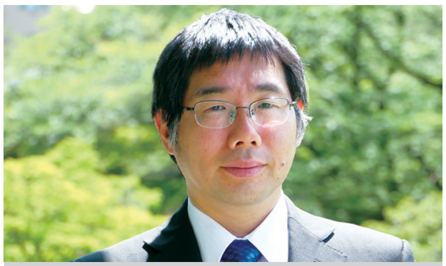
Reduction of Elastic Vibration of Car Bodies and Internal Noise



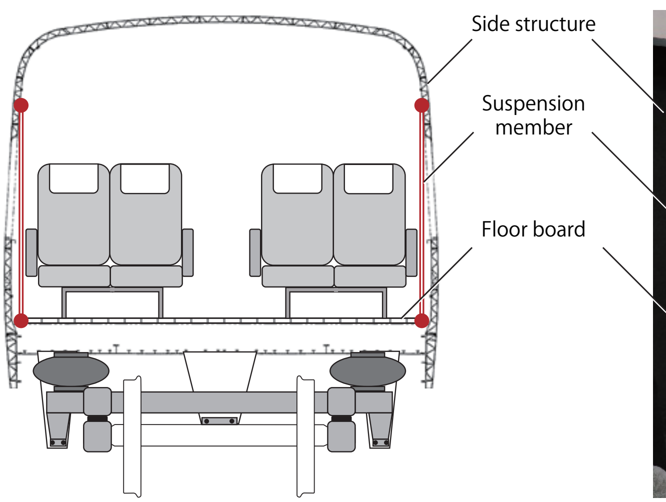
Dr. Katsuya Yamamoto
Laboratory Head
Vehicle Noise and Vibration

Dr. Yoshiki Sugahara
Chief Researcher
Running Gear

Ride comfort and noise are two of the most significant factors affecting train passengers' overall comfort. Frequencies of vibration from several Hz to several dozen Hz affect ride comfort and those from several dozen Hz to several kHz affect noise. To offer higher comfort to passengers, appropriate measures must be taken to mitigate the magnitudes of these factors.

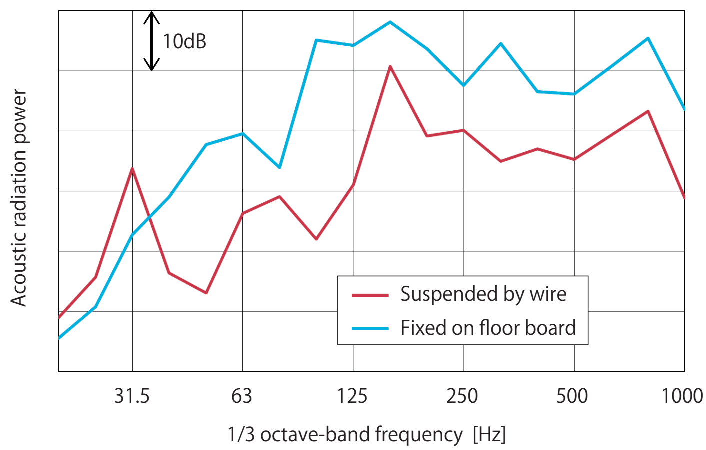
Reducing internal noise in vehicle

The internal noise of railway vehicles can be divided into structure borne sound, which is generated as the vibration of bogies etc. is transmitted to the floor board and interior decoration, and sound transmitted from the outside through the bodyshell and interior decoration. Since noise reduction measures vary depending on the types of noise, a suspended floor has been devised to reduce the structure borne sound transmitted through the floor board. The floor board, which is normally supported by the floor structure, is instead suspended from the side structures. With this method, the vibration of the floor board is expected to be reduced as structure borne sound comes only through the side structures, whose vertical vibration is moderate.



The floor board is suspended from the side structures to reduce the structure borne sound.

RTRI conducted an experiment of the suspended floor with a Shinkansen type test vehicle.



The comparison of the power of floor board vibration shows that the suspended floor board can reduce the structure borne sound in the range below 1000 Hz.

RTRI made a test vehicle installing a suspended floor to conduct an experiment. In the experiment, wires were used as the suspension members. The power is calculated from the measured floor board vibration in a stationary vibration test. The results indicate the power is around 5–10 dB lower on the suspended floor structure in the range below 1000 Hz.

Reduction of Vertical Vibration of Vehicles through Control Technology

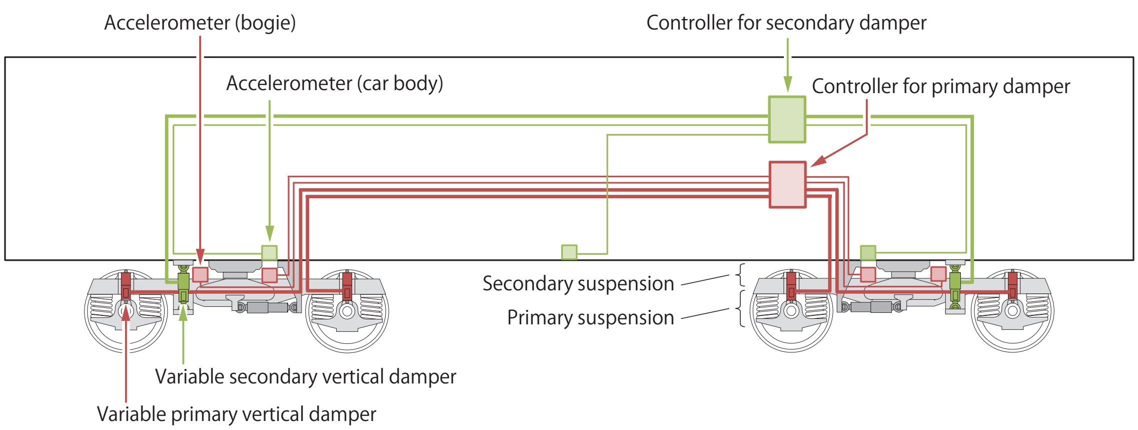
In general, as train running speeds increase, vibration contributing factors grow in intensity, causing vehicles to vibrate more severely and reducing ride comfort. One of the most effective technologies involved in maintaining ride comfort under such conditions is the "vibration control system", which is installed on nearly all Shinkansen vehicles to counter lateral vibration. As a result, lateral ride comfort has even been improved on Shinkansen vehicles despite the fact that they now run faster than ever before. On the other hand, no solutions have ever been introduced that substantially improve vertical ride comfort. With that in mind, RTRI has been active in developing a vertical vibration control system for high-speed trains.

Vertical vibration damping system configuration

The diagram immediately below shows the vertical vibration damping system being developed for high-speed trains. The sub-system shown in green measures vertical vibration of the car body and controls the dampers installed between the car body and bogies in such a way as to reduce the vibration. The other sub-system, shown in red, measures vertical vibration of the bogies and, based on the measurements, estimates the elastic vibration of the car body (which is accompanied by car body deformation) and controls the dampers installed between the axle boxes and bogies in such a way as to reduce the vibration.

Results of vibration testing using an actual vehicle

To verify the system's intended performance, the system was installed on a vehicle equivalent to the real Shinkansen



The vertical vibration damping system, which consists in principle of two sub-systems, is capable of reducing vibrations (parallel vertical movement, pitching, rolling and primary flexural vibration) typically generated on vehicles running at high speed.

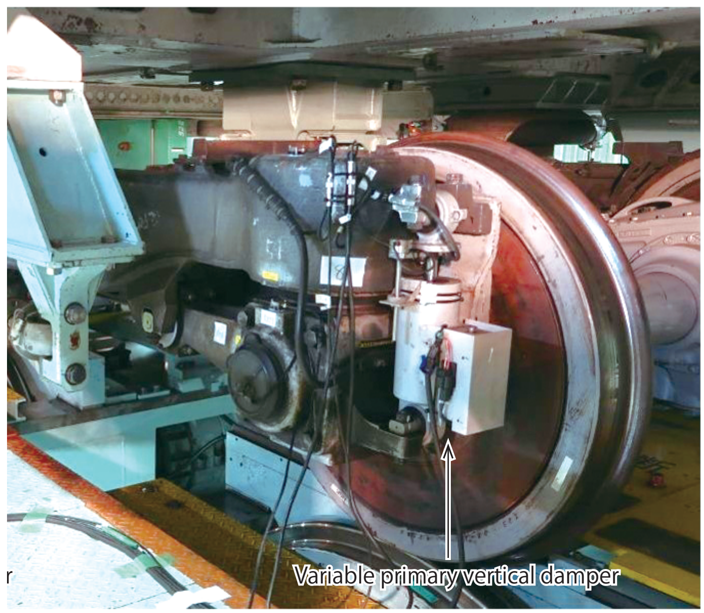
vehicle and the assembly was subjected to vibration testing simulating actual operation on the Shinkansen track. The results showed substantial reduction of vertical vibration of the car body and improved ride comfort.

Future plans

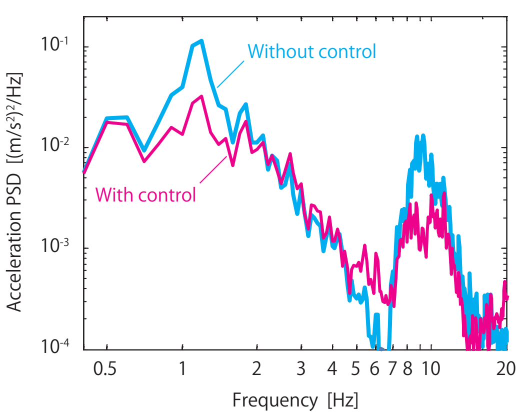
Based on the results obtained, the system will be improved further for testing on actual Shinkansen vehicles. Efforts will be continued to ultimately utilize the system in practical applications, thereby helping to improve the ride comfort of high-speed trains and, more broadly, the quality of service.

Conclusion

Solutions to ride comfort and internal noise issues need to be, in general, lightweight, low-cost and something that will not substantially alter the current structure. That increasingly leaves us with few options that appear readily applicable, making it more plausible to try something totally new. Going forward, we will plan to expand our field of vision in our R&D to include possibilities that appear even a little unusual and continue our efforts for practical application.



A prototype of virtical vibration damping system was tested on the rolling stock test plant in RTRI.



The graph shows examples of vertical vibration reduction by the system as measured directly above a bogie in the vibration test. Both rigid-body vibration (not accompanied by car body deformation) at around 1 Hz and elastic vibration (accompanied by car body deformation) at around 9 Hz are shown to be substantially, thus achieving improvement in ride comfort.