A Ride Comfort Evaluation Method to Reflect the Effect of High-Frequency Vibration

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The ride comfort level (RCL) is a typical index used to evaluate the ride comfort of trains in Japan railways. When applied to the evaluation of high-speed rolling stock in recent years, however, the existing method of calculation yields results that do not always agree with the sensation felt by humans. This is because the high-frequency components (about 30 Hz) that are characteristic of the vibration of recent high-speed trains are not properly reflected in the RCL obtained by the existing method. These higher frequencies have a considerable effect on ride quality felt by humans.

Thus, we investigated human reaction (called “human sensibility”) to vibration in the 1 to 50 Hz band using “discomfort feeling” as a ride comfort scale using Electrodynamic vibration system (Fig. 1) to confirm that (1) human sensibility to high-frequency vibration is stronger than assumed in the existing RCL and (2) it tends to change to a certain degree irrespective of seat categories (Fig. 2) or seating postures. Based on these findings we have adopted new ride comfort filters that have been improved to emphasize the effects of high-frequency components of vertical and longitudinal vibrations (Fig. 3).

To verify the validity of the improved ride comfort filters, we implemented a running test of a Shinkansen car boarded with 30 test subjects to examine the correlation of the test results obtained with the new filters with those recorded through subjective evaluation. As a result, we confirmed that the RCLs determined with the new filters are higher than those determined with the existing filters in all evaluation sections, are in good agreement with human sensation and correlated better with human sensation than those determined by using the existing filters (Fig. 4).

Additionally, through another test on a vibration system to reproduce the vibration of Shinkansen and narrow-gauge cars in service, we again confirmed that the RCLs evaluated by using the new filters are larger than those obtained by using the existing filters and produced improved correlation with the results of subjective evaluation when vibration contains high-frequency components in quantities similar to Shinkansen cars. However, we also found that where there are few high-frequency vibration components, such as in narrow-gauge cars, the RCLs obtained with the new filters are approximately the same as those obtained by using the existing ones.

We also investigated the effect of the noise in 30 to 100 Hz band existing in the same frequency band as that of vibration to clarify that low-frequency has virtually no effect on the evaluation of running vibration in wide frequency bands.

Based on the above findings, we have reached the following conclusions.

To apply the existing ride comfort evaluation method in practice to obtain evaluation results in agreement with human sensation, it is sufficient enough to replace the existing ride comfort filters with the improved ones, while using the existing scales and calculation methods. When the vibration to be evaluated contains few high-frequency components, the values obtained by using the new filters are comparable with those obtained in the past when using the existing filters.

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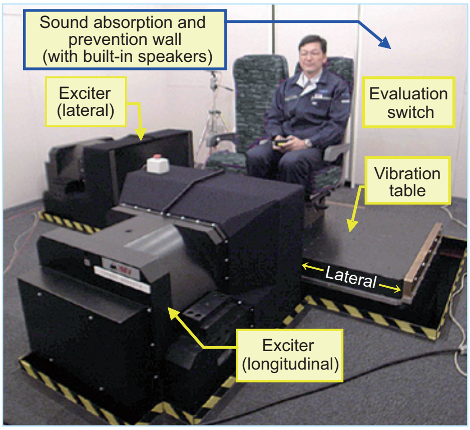

Fig. 1 Electrodynamic vibration system and a subject sitting on a double seat

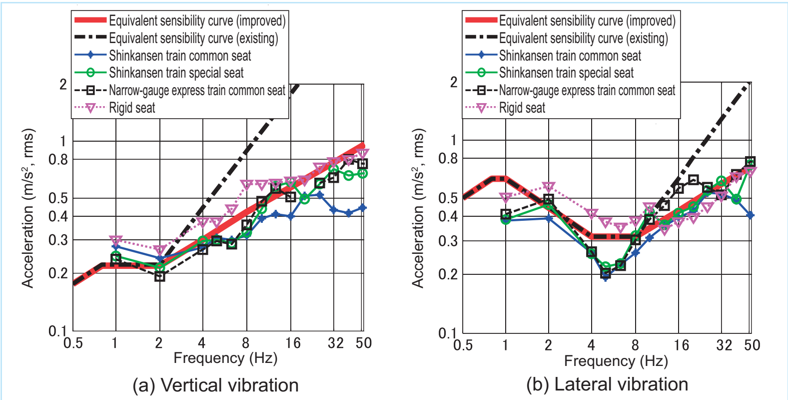

Fig. 2 Average allowable limits (test results) and the equivalent sensibility curve

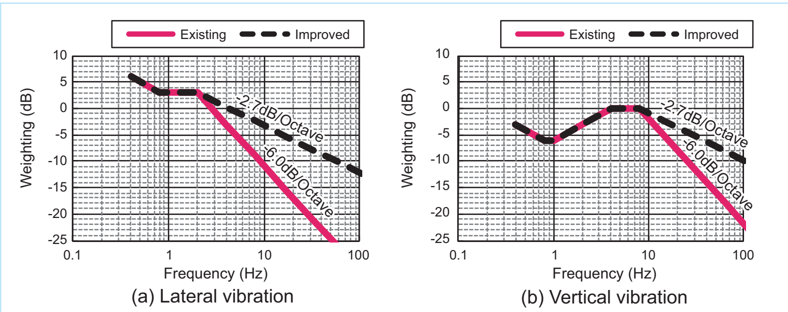

Fig. 3 Ride comfort filters (existing and improved)

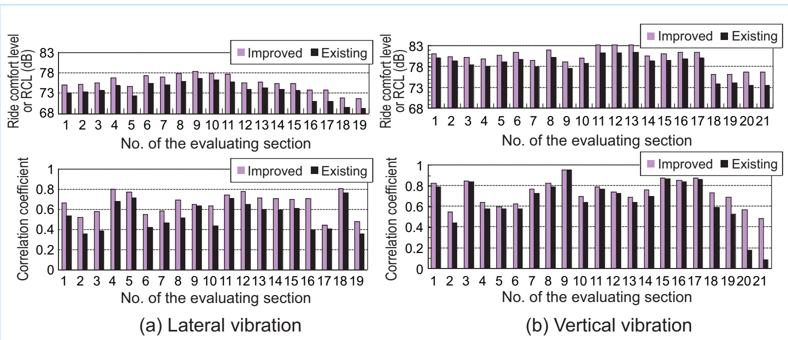

Fig. 4 Correlation coefficient between the ride comfort levels obtained through subjective evaluation and measured in running tests