High-precision Prediction of Tunnel Micro-pressure Wave Based on Theoretical Analysis

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When a high-speed train enters a tunnel, a micro-pressure wave is radiated from the tunnel exit to potentially cause an environmental problem. The author's group is now developing a high-precision prediction method of micro-pressure wave based on theoretical analysis.

1. Micro-pressure wave

When a train enters a tunnel at high speed, a compression wave is generated in the tunnel (see Fig. 1(a)), and propagates through the tunnel while changing its shape (Fig. 1(b)). When the compression wave reaches the tunnel exit, a micro pressure wave is radiated outside of the tunnel (Fig. 1(c)). The micro-pressure wave may accompany a blasting sound and excite vibrations in neighboring buildings. As micro-pressure waves are highly speed-dependent, preventive measures are required for speed-up of trains. Thus, it is essential to predict the magnitude of the micro pressure waves.

2. Method for prediction of micro-pressure wave

To evaluate the micro-pressure wave, our group has developed a method of high-precision prediction based on non-linear acoustic theory for the three stages of micro-pressure wave generation: (a), (b), and (c) in Fig. 1 (which are referred to as the stages 1, 2 and 3, respectively, below). Figure 2 illustrates an example of the prediction results obtained by our method which combines three prediction techniques for the stages 1, 2 and 3. Here we considered the case where the train speed is to be increased from 245 to 300 km/h. As a countermeasure for the micro-pressure wave, a tunnel entrance hood with side windows is to be installed at the tunnel entrance. The purpose is to keep the peak value of the micro-pressure wave at 300 km/h equal to or less than that at 245 km/h.

Figure 2 shows the prediction results for the original case (with no tunnel entrance hood, 245 km/h) and for the two hood condition cases (300 km/h), with symbols A and B standing for two different window patterns. For the short tunnel, the peak value of the micro pressure waves are almost the same among the three cases. On the other hand, in the case of a long slab tunnel, the peak values of the micro-pressure wave for the window pattern A case is approximately twice as high as the original case, while those of the window pattern B case and the original case are about the same. In this manner, our method makes it possible to evaluate the performance of micro-pressure wave reducing measures for various conditions of tunnels.

3. Novel measures to reduce micro pressure waves

In the course of the development of the prediction method, our physical understanding of the micro-pressure wave phenomenon has advanced greatly. Taking advantage of this, our group will develop novel measures to further reduce micro-pressure waves in Shinkansen, where train speed is ever increasing.

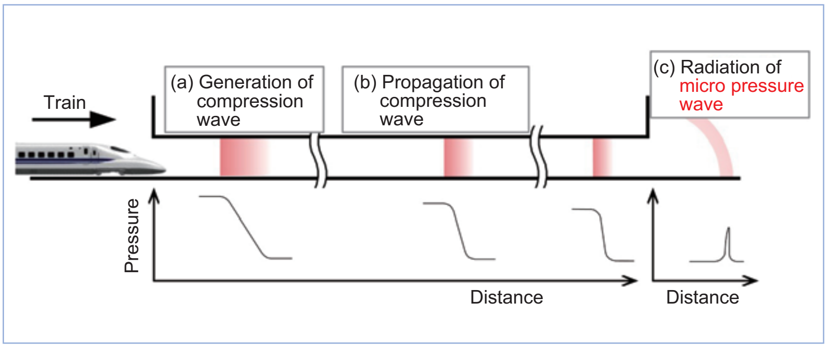

Fig. 1 Radiation of micro pressure wave

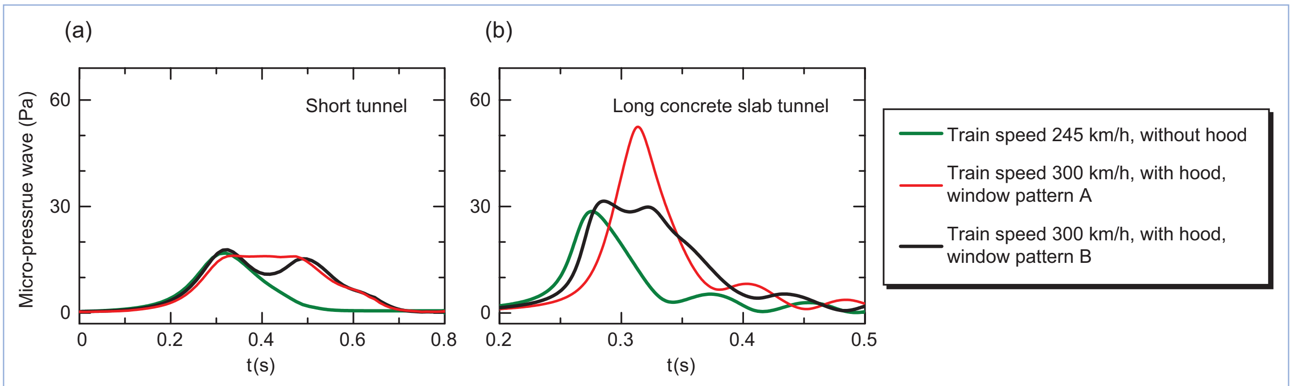

Fig. 2 An example of prediction results of micro-pressure wave at tunnel exit