Observation, Experimentation and Analysis of Pressure Waves Generated When a Train Passes a Nearby Structure

Hajime TAKAMI
Assistant Senior Researcher, Aerodynamics, Environmental Engineering Division

Low-frequency sounds are slight pressure fluctuations with frequencies in the range of approximately 1 to 100 Hz. They are hardly perceptible to the human ear, yet have given rise to concern in Japan over the last decade because they can cause the rattling of house windows and shutters, and can also cause physiological and psychological discomfort, such as ringing in the ears and an unpleasant sensation of pressure.

Micro-pressure waves generated at tunnel portals when a high-speed train enters a tunnel have long been observed along railway lines as low-frequency sounds. But even along some open sections of line, pressure waves may be radiated from a nearby structure when a high-speed train passes. These pressure waves, in the form of weak low-frequency sounds, do not cause a problem at present, but they could negatively affect the adjacent environment when trains operate at even faster speeds in the future.

Our research team therefore conducted on-site measurements along open track sections to examine phenomena when a high-speed train travels under an overpass (Fig. 1). We measured pressure waves that differed according to train speed, overpass size, and the location of the observation point.

We then performed experiments using a model scale apparatus and conducted acoustic analyses, to determine the speed dependencies, distance attenuation and directional characteristics of pressure waves. We were able to show that mechanisms generating pressure waves involve both micro-pressure waves and a combination of waves generated when the train enters and leaves the portals (with the overpass acting as a short tunnel). We used this knowledge to analytically predict the characteristics of pressure waves radiated from an overpass that is long enough to possibly cause a problem during high-speed operations. Predicted values agreed well with the results of our experiments (see Figs. 2 and 3).

This research has further improved the methodology for analyzing pressure waves, thereby aiding in the prior determination of trackside low-frequency sound and pressure wave conditions that would exist under higher speed operations for Shinkansen and other high-speed trains.

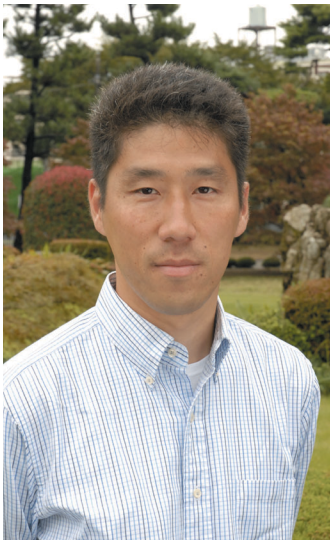

Fig. 1. Overpass

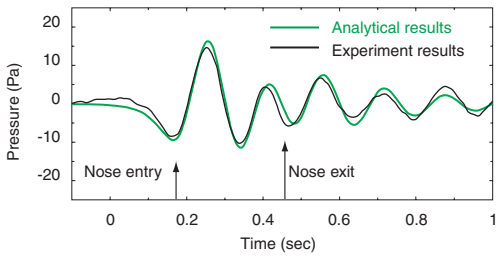

Fig. 2. Pressure waves observed during experiments and determined through analysis
[Train velocity 350 km/h; overpass width 24 m]

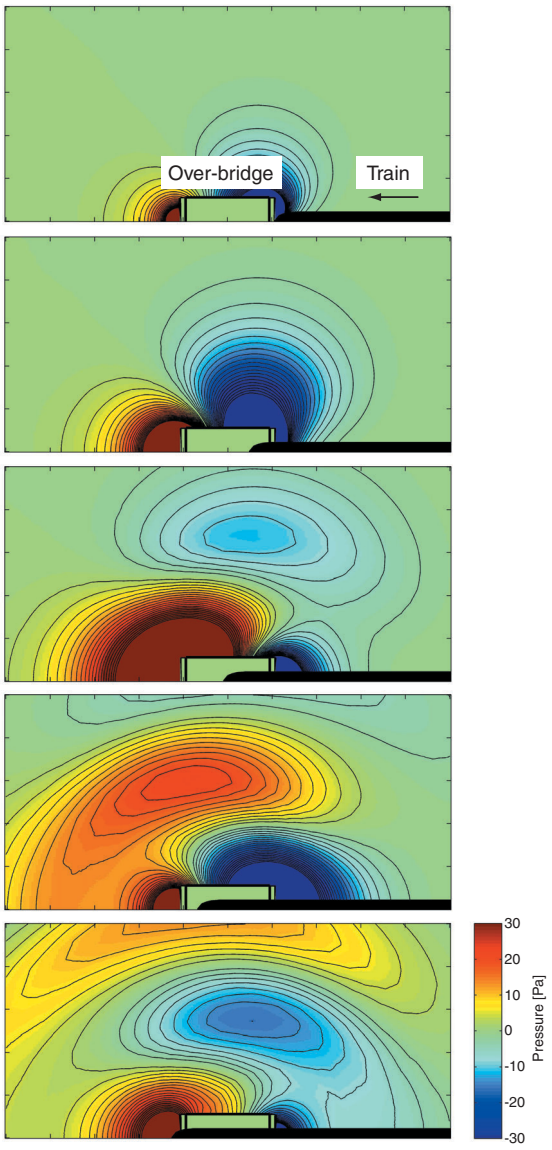

Fig. 3. Spatial distribution of instantaneous acoustic pressure, obtained by analysis
[Train velocity 350 km/h; overpass width 24 m]