Designing Railway Noise Barriers to Account for Resonance due to Train Draft Pressure

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1. Purpose and Background

To guarantee the environment-friendly performance of high-speed trains and to help protect them from snow in some circumstances, noise barriers are becoming increasingly taller to more than rail level +3.0m as new barriers are installed and existing low-rise ones are remodeled. Noise barriers for railways have been designed so far based on a simple static check to withstand a design wind load of 3.0kN/m^2 in strong winds (wind speed 50m/s). For tall noise barriers, however, there are concerns about resonance of the barriers due to decreases in rigidity and the emergence of other unsolved phenomena. Thus we investigated the response mechanism of these barriers at higher train speeds in order to compile reasonable technical design standards.

2. Understanding the response mechanism of noise barriers

(1) Measurement at site

The typical tall noise barrier has concrete panels trapped between H-shaped steel struts that are embedded in the RC bridge railing as shown in Fig. 1. Through measurements made at the site we identified the natural vibration mode of this noise barrier, quantified the train draft pressure formed at the head and tail of passing trains and assessed the phenomenon of subsequent resonance amplification of the strain at the bottom of the H-shaped struts.

(2) Analysis of dynamic interaction between trains and structures

We constructed a model to analyze the dynamic interaction between trains, tracks, structures and noise barriers. The model reproduced the results of impulse excitation recorded during the train running tests and allowed us to analyze and extract response-governing factors through numerical simulation. As a result, we were able to clarify that the response of tall noise barriers to train passage is (a) governed by the resonance between the noise barriers vibrating at the natural frequency and train draft pressure formed at the head of the train and (b) amplified by the overlapping effect of the tail pressure pulses (Fig. 1).

3. Generalization of dynamic response of noise barriers

As there are a great number of noise barriers and railway structures existing in combination, we extracted factors governing the resonance phenomenon based on the knowledge acquired above and developed a multi-body model that links springs, masses and dampers. The model allows us to express the behavior of noise barriers in simple terms (Fig. 2). By using this generalized model, we implemented a large-scale parametric analysis and proposed a design train wind pressure load for noise barriers based on their natural frequency and train speed. As an example, Fig. 3 indicates that, for a train speed of 260 km/h, the design train pressure load exceeds the value specified for strong winds in the existing standards when the natural frequency of the barrier is lower than 3Hz.

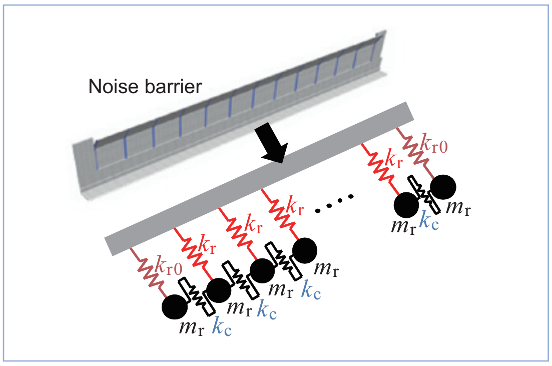

Fig. 2 A noise barrier generalization model

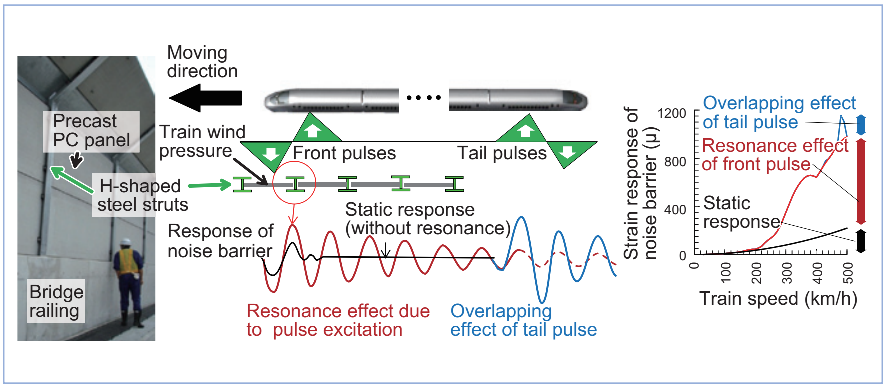

Fig. 1 A typical tall noise barrier and mechanism of resonance amplification

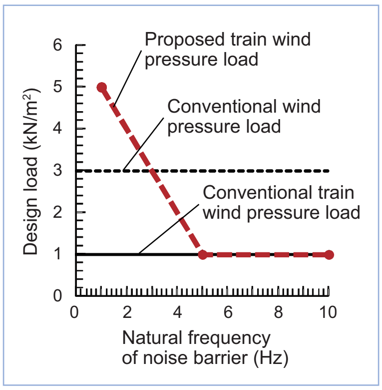

Fig. 3 Design train wind pressure load (train speed 260km/h)