A Method to Estimate the Efficiency of Ground Vibration Reduction Wall

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Among the various countermeasures for rolling stock, tracks and structures that have been discussed to prevent the ground vibration along railway lines, burying a wall in the ground is expected to be a comparatively effective solution to cut off vibration. Since the effect of vibration isolation work depends on the ground conditions and the materials, size and other conditions of wall-in-ground, however, there are no quantitative designing methods established to isolate vibration. Therefore, we reviewed the results of model experiments and field tests in the past from a new viewpoint and developed a method to quantitatively evaluate the effect of vibration isolation work as described below.

OUTLINE OF THE EVALUATION METHOD

In planning and designing vibration isolation work, it is desirable to have a simple and convenient method to evaluate its effect. Thus, we composed a moderately simple theoretical model to evaluate the effect of vibration isolation work in quantitative terms. This model features the following (Fig. 1):

(1) Assumes that a surface wave (Rayleigh wave) is generated from the ground vibration and that the vibration energy behind the wall-in-ground is the sum of the energy of the transmitted wave through the wall and the energy of the diffracted wave originated from its side and bottom.

(2) Applies Kirchhoff's diffraction theory, which is introduced in the fields of optics and acoustics, to the evaluation of the diffracted wave.

(3) Applies the one-dimensional wave transmission theory that is normally used and the beam deformation theory by regarding the wall-in-ground as a beam to calculate the transmission rate of the wave transmitted through it. Since it is far simpler than the numerical analysis by the finite element method (FEM), the newly developed evaluation method will be useful for planning and designing vibration isolation work along railway lines.

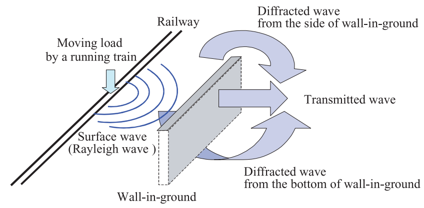

Figure 1. Schematic illustration of transmitted and diffracted waves by the wall-in-ground.

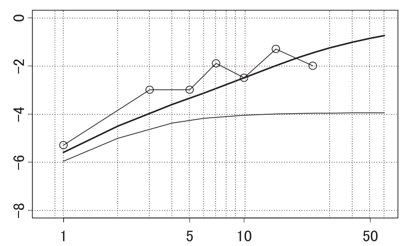

Figure 2. Estimation of vibration reduction by wall-in-ground. The wall is a concrete wall and has a depth of 3 m, a thickness of 1.2 m and an extension of 80 m. Estimated reduction (1) is obtained by using the diffracted wave from the bottom of wall-in-ground and the transmitted wave. Estimated equation (2) is the estimated equation (1) corrected for the diffracted wave from the side of wall-in-ground.

VERIFICATION WITH MEASUREMENT DATA

To verify its validity, we applied the evaluation method to 13 model experiments of vibration isolation work in the past and seven field-execution tests in Shinkansen viaduct sections. As a result, the actual effect to isolate vibration was reproduced through calculations in consideration of the diffraction wave that comes from the bottom of the vibration isolation structure and the wave transmitted through it in the vicinity from the structure to a place 5-m distant therefrom, and can quantitatively be evaluated by correcting the calculations for the diffraction and transmitted waves with respect to the effect of the diffraction wave from the side of the structure beyond the said point (Fig. 2).

TRIAL DESIGNING OF VIBRATION ISOLATION STRUCTURE

We applied this evaluation method to the construction of a concrete wall-in-ground under the actual ground conditions indicated in Fig. 3 (normal ground at the site A and soft ground at the site B) and found that:

(1) The effect of vibration isolation structure of the same size is different for different ground conditions (Fig. 4).

(2) Deeper structures are more effective up to a ceiling point, beyond which the effect is not proportional to the depth.

(3) Longer structures are more effective (Fig. 5).

Since the effect of vibration isolation work is significantly different for different ground conditions as mentioned above, it is important to design an effective vibration isolation structure most appropriate to the object site.

POSTFACE

According to the researches and studies hitherto carried through on the countermeasures against the vibration along railway lines, it is possible to quantitatively evaluate the effect of lightweight vehicles, tracks with a low spring constant, and vibration isolation structures. In addition, there are various categories of vibration isolation work that are still at the stages of basic discussions, experiments, and numerical analyses. We will promote research and development on such categories of vibration isolation work and establish a manual for countermeasures against vibration to be consulted for selecting the vibration isolation work that best suits the actual conditions of ground vibration.

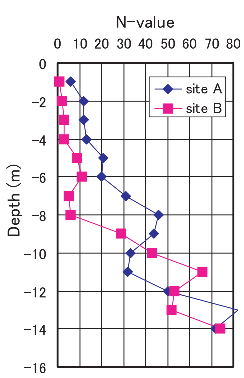

Figure 3. N-value profiles at the sites A and B.

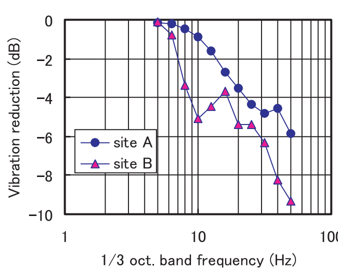

Figure 4. Estimated frequency spectra in the 1/3 octave scale of vibration reduction by the wall-in-ground at a point 1-m distant from the wall-in-ground. The wall-in-ground has a depth of 3 m and a thickness of 0.8 m.

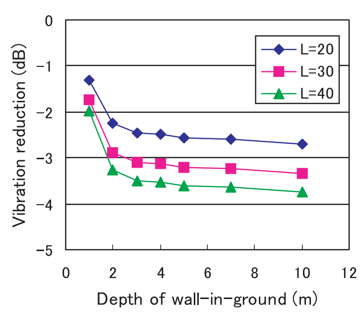

Figure 5. Estimated vibration reduction by the wall-in-ground at a point 12.5-m distant from the track. L means the length of wall-in-ground (unit: m).