SECTION 1. Comparison between Measurement and Prediction of Ground and Structural Vibration Induced by Train Load

Kyoto University M. JSCE ○Kyoung-Lae Park
Kyoto University M. JSCE Eiichi Watanabe

1. Introduction

Wave propagation and vibration caused by the passage of trains are influenced by many parameters such as the characteristics of train, structure of railway system, propagation characteristics of elastic wave and soil-structure interaction effect. From this reason, it is very complicated or impossible to estimate wave propagation and vibration in soil media and adjacent structures. In this study, an analytical method consisting of two procedures is proposed and verified with measured data to predict vibration in such media. One is the estimation of dynamic force caused by train and the other is the analysis for wave propagation and vibration considering soil-structure interaction effect.

2. Method of This Study

2.1 Analysis

In the evaluation of running train load, the method that Kraemer had presented is used for calculation of roughness spectrum of irregular running surfaces of wheel and rail. Admittance of vehicle is modeled by one-mass model considering only the vehicle mass on the spring. Admittance of rail is modeled in 2-layer continuous model with elastic sleepers under moving axle loads as shown in Figure 1. PSD of the dynamic force transmitting to substructure through the track system is as follow:

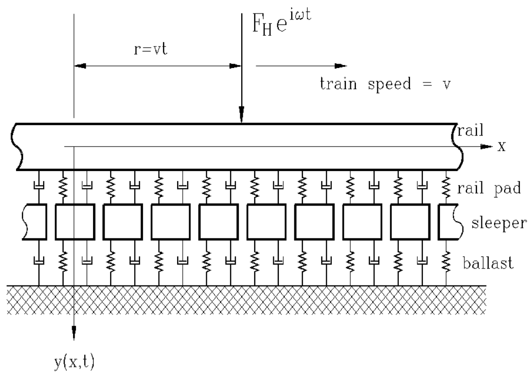


Figure 1. Modeling of Rail

$$\hat{F}_p(\omega) = |k_b^*|^2 \, \hat{Y}_{ts}(\omega) = |k_b^*|^2 \left\{ \hat{Y}_{qs}(\omega) + \hat{Y}_{rs}(\omega) \right\}$$

where, k_b^* = complex stiffness of ballast; $\hat{Y}_{qs}(\omega)$ = PSD of deformation of sleeper caused by moving axle loads; $\hat{Y}_{rs}(\omega)$ = PSD of deformation of sleeper caused by rail roughness.

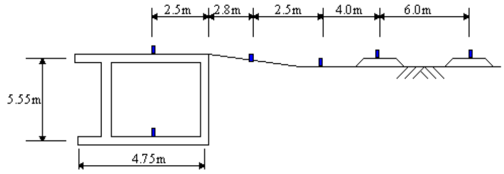


Figure 2. Measuring Section 1

To analyze wave propagation problem in soil media using conventional finite element method, one must employ a truncated model of soil media even though it may extend to infinity. Truncated boundaries must be modeled using appropriate energy-absorbing boundaries to simulate radiating wave property. In this study, structure and soil media near source of vibration are modeled using 2-dimensional finite elements and thus, 2-dimensional dynamic infinite elements are used to simulate radiating waves.

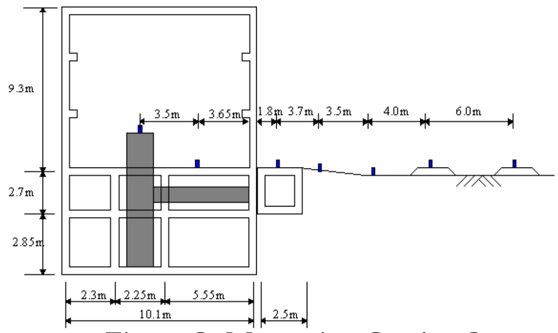


Figure 3. Measuring Section 2

2.2 Measurements

Measurements of vibration caused by passing train was carried out in the structures of the Si-Hung pumping station (in Korea) and ground near to them. Figure 2 and 3 show the location of railways (source of vibration), section of measured site and arrangement of accelerometer.

---

3. Verification

To calculate equivalent forces for wave propagation analysis, PSD of dynamic force transmitting to substructure must be calculated firstly. The Source which was chosen for this study was subway train between Seoul and Suwon and material properties were assumed using the data derived from the specification of Korean subway. Calculated PSD is shown on Figure 4. Structures and ground are modeled with finite elements and infinite elements as shown in Figure 5. and Figure 6.

Analytical results were compared with 3 measured data in section 1, and Figure 7 shows these results. They represent that level of vibration dependent upon distance of source of vibration. Especially, components of relatively higher frequency decrease rapidly. Although predicted results show a little bit higher level of vibration, those results agree well and predicted results can be considered conservative.

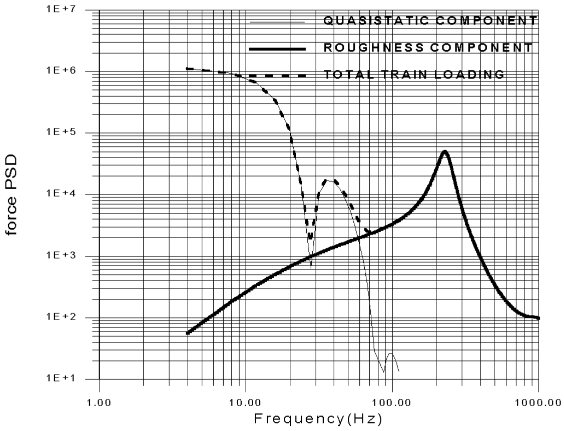


Figure 4. PSD of Rail Load

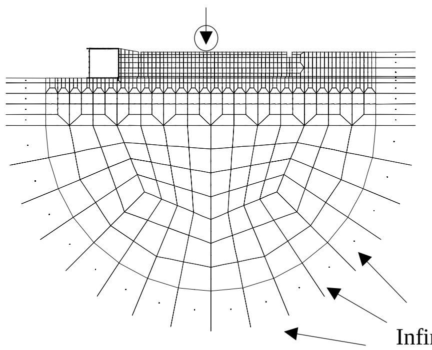


Figure 5. Modelling of Section 1

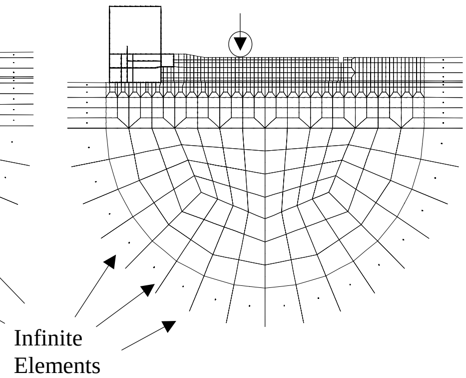
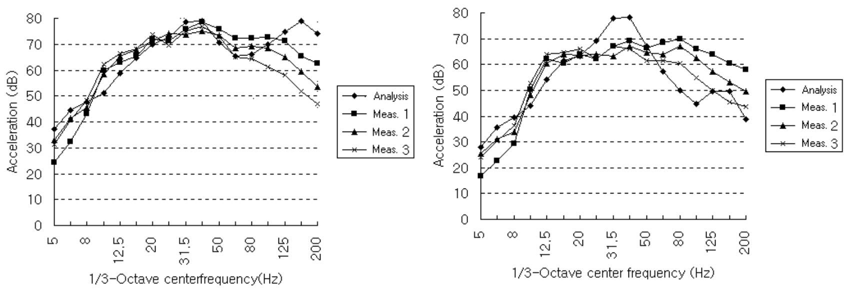


Figure 6. Modelling of Section 2



(a) At 4.0m (b) At 6.5m

Figure 7. Comparison between measurement and analysis

4. Conclusions

In this study, calculation of dynamic force caused by train using the method that had been proposed early and analysis using the method that is suitable for soil-structure interaction problem were carried out and vibration in structure and soil was predicted using these methods.

Predicted results were compared and verified with measured data. Comparison between predicted and measured data gives good agreement and analytical method may be adaptable for prediction of vibration in soil and structure. Although predicted data give higher level, it can be considered as conservative result. However, more detailed modeling technique must be developed to get more reasonable result.

5. References

Chau, K. H., Balendra, T. and Lo, K. W., (1992), “Groundborne Vibrations due to Trains in Tunnels”, Earthquake Engineering and Structural Dynamics Vol.21, 445-460

Lee, J. H., Park, K. L., Park, K. S., Yang, S. C. (1998), “Measurement and Prediction Analysis of Ground and Structural Vibration Induced by Train Load,” Proceedings of the Korean Society for Noise and Vibration Engineering, 273-276 (In Korean)