Zukunft Bau

Short Version/Summary Report

Titel

Prediction of structure-induced secondary airborne noise from rail traffic

Motivation

The prediction of structure-induced secondary airborne sound is very difficult, due to i) the transmission of structure-borne noise from the ground via the foundation into the building and ii) the sound emission through the relevant space boundary surfaces. As a result, there are very high inaccuracies in the prediction in practice.

Description of the research project

Complex calculations and numerical simulations were carried out and validated with measured results. For this purpose, appropriate measurements were realized within the scope of the project. The results were then translated into a practical approach to predict secondary airborne sound in rooms.
The interaction between soil and structure was examined by numerical calculations for the frequency-dependent soil-structure interaction for plate and pile foundations in the soil half-space to determine the transmission of soil (pile) foundation. The detection of these interactions takes place with the help of analytical and numerical methods for the dynamic response of soil-foundation-building-systems. Approximations for the dynamic stiffness of shallow foundations were developed through numerical investigations. The basic value concerns foundations on the surface of the subsoil; the influence of the embedding is taken into account by an increase factor. Theoretical investigations showed that the interaction between the piles can dramatically influence the global rigidity of the foundation. The pile-soil interaction was then experimentally investigated on a model scale and on a 1: 1 scale. For this purpose, a pile was loaded within a pile group and the response signals of the surrounding piles were measured and subsequently evaluated.
Furthermore, numerical parameter studies were used to investigate the vibration propagation as a result of above-ground rail traffic and its effects on existing buildings. The FE program Plaxis 2D was used for this purpose. Considered a multi-storey structure, which is embedded in the underground. Homogeneous conditions and a double-layered soil structure were considered for the subsoil situation. The effects of a shielding of vibrations by a passive insulation in the form of an open bottom slit were additionally examined for the homogeneous case.
Structural dynamic calculations were carried out to predict shocks and structure-induced secondary airborne sound for a planned residential complex. Measured vibration signals from the passing of trains in the area of a multi-track, highly frequented railway line were used as input signals for the calculations. The prognosis of vibrations and secondary airborne sound was first given in accordance with the directive 800.25-01 to 05 "Vibrations and secondary airborne sound" of Deutsche Bahn AG. On the basis of elaborate structural-dynamic calculations, in an individual calculation model of soil and structure including the pile foundation, the prognosis reliability with regard to the transmission of vibrations from the ground via the foundation to the building, inside the building as well as the excitability of floor slabs and walls was examined in more detail. The three-dimensional FE calculations were carried out using the finite element program SAP2000.
Furthermore, structural dynamic calculations to determine the vibration characteristics of the different space-limiting surfaces (wall, ceiling, etc.) of a test reference building in a test stand at the University of Kaiserslautern have been made as an example. In the test reference building, the secondary airborne sound was simulated by a low-frequency sound source and the sound propagation and transmission in the test building were measured and compared with calculation models. For this purpose, the sound emission level of the room boundary surfaces for the low frequency range was calculated in detail. The estimation of the flank sound attenuation required for the secondary sound prognosis was made by building acoustic measurements and calculations in the test reference building.
In order to verify and test the forecast models, in-situ vibration measurements in the ground and in the building were carried out in collaboration with the practice partner. In the floors and rooms most affected by the secondary airborne sound, the floor vibration was recorded and at the same time the resulting sound pressure level was measured. With the measured reverberation time in the examination room, the sound pressure level could then be predicted and compared with the experimentally determined one.

Conclusion

The aim is to develop methods to improve the prognosis of secondary airborne sound in practice with the currently available soil/building dynamic and building acoustic calculation algorithms as well as the modern measurement techniques in combination with already existing knowledge from measurements on real buildings. It can be seen that the application of an energy-based approach to secondary sound prognosis significantly improves forecasting accuracy. However, further investigations must be carried out, especially the component soil-structure interaction for further constructions and the investigation of the radiation behavior of solid and lightweight combinations. (717 Zeichen)

Data

Short title: Prediction of secondary airborne noise

Researcher/Project Manager:
Technische Universität Kaiserslautern, Fachgebiet Bodenmechanik und Grundbau Prof. Dr.-Ing. habil. Christos Vrettos;
Technische Universität Kaiserslautern, Fachgebiet Bauphysik Prof. Dr. rer. nat. Oliver Kornadt;
baudyn GmbH Hamburg

Total cost: 226.994,76 €

Contribution made by the Federal Government: 131.004,76 €

Project duration: 28 months

Pictures/ Figures:

Picture 1: Bild 1.jpg
Versuchsaufbau im Labor mit eingebetteten Modellpfählen zur Untersuchung der Pfahl-Boden-Interaktion

Picture 2: Bild 2.jpg
Versuchsaufbau im Feld mit eingebetteten Spundwandprofilen zur Untersuchung der Pfahl-Boden-Interaktion im Maßstab 1:1

Picture 3: Bild 3.jpg
Versuchsaufbau im Labor mit eingebetteten Spundwandprofilen zur Untersuchung der Pfahl-Boden-Interaktion

Picture 4: Bild 4.jpg
Numerische Untersuchungen zur Erschütterungsausbreitung infolge von oberirdischem Schienenverkehr

Picture 5: Bild 5.png
Prüfstandes an der TU Kaiserslautern zur Untersuchung des Test-Referenzgebäudes

Picture 6: Bild 6.png
Prinzip der Messung der Oberflächenschnelle mit einem Scanning-LDV

Picture 7: Bild 7.png
Beispielhafte Messsituation bei der Messung in einem realen Gebäude zur Verifikation der Ergebnisse