FACHHOCHSCHULE **HOCHSCHULE FÜR**
STUTTGART **TECHNIK**

Fachbereich Bauingenieurwesen, Bauphysik und Wirtschaft
und
Joseph-von-Egle-Institut für Angewandte Forschung

abridged report
No. 132-007-02P-abridged

Measurement and Prognosis of the Structure-Borne Sound Transmission of Sanitary Installations

Stuttgart, 1st July 2005

Editor: Project director:

M. Späh, Dipl.-Ing.(FH) Prof. Dr.-Ing. H.M. Fischer

Since years, the sound produced by sanitary installations can be regarded as one of the most critical areas of noise control in buildings. This is due to the fact that such sources can produce highly annoying sounds in buildings and, on the other hand, there are great uncertainties in the assessment of the sources and the prediction of sound produced by sanitary installations. In order of the new European standardisation and the necessary renewal of the German standard DIN 4109, the possibility of a fundamental analysis of structure-borne sound transmission arose. In this research project the attempt was made to generate a physical and practical method for characterisation of structure-borne sound sources, generating input data for prediction models in buildings.

For the prognosis of the sound transmission in buildings usually two datasets of input data are needed: data of the source and data for the transmission of the sound in buildings. Based on the physics of structure-borne sound, different approaches to characterise structure-borne sound sources are described. Following this analysis, based on the reception plate method, a three dimensional laboratory has been developed. With this laboratory, structure-borne sound sources can be characterised by their structure-borne sound power. This characterisation is practical, physically correct and enables the generation of input data for existing prediction models.

The developed laboratory consists of three mutually perpendicular separate plates, representing a corner situation of a room. This enables the characterisation of sources, which are connected to more than one building element like corner baths, without the rearrangement of the source. The structure-borne sound power of the source can be measured simultaneously for up to three building elements. The measurement of the structure-borne sound power with the reception plate method was verified with two different sources by evaluation of different power methods. The utilised sources where a force source applied by an electro-dynamic shaker and secondly a whirlpool bath. The comparison of the structure-borne sound power measurements by the reception plate method at the laboratory and the other methods showed a very good agreement and verified that the laboratory gives exact structure-borne sound power data at mid and high frequencies. Even at low frequencies the structure-borne sound power data proved reasonable good.

The structure-borne sound power data of the laboratory can be transformed into the characteristic power, which compensates for the properties of the finite plate characteristics at the contacts. The characteristic power enables the comparison of different sources and the measurement at different laboratories. It generates the possibility of product comparison and product enhancement in regard to their structure-borne sound power. The characteristic structure-borne sound power can be transferred into input data of prediction models and therefore enables the prediction of sound pressure levels in buildings, caused by installations and other structure-borne sound sources.

As a second essential part of this project, the transmission of structure-borne sound in buildings is analysed. The prediction model of EN 12354 part 5 is presented and the connection to the model of statistical energy analysis (SEA) is described. In addition to these prediction models a new method is described, the global power transfer function ($GLTF_n$). This transfer function can be generated by the prognosis model of EN 12354 part 5, a SEA model or by measurements in buildings. For defined transmission situations, the $GLTF_n$ enables in combination with the structure-borne sound power input data, a simple prognosis of the normalised sound pressure levels in buildings.

Using the input data for structure-borne sound sources, the prediction model of EN 12354 part 5 is applied for a building like diagonal transmission situation. For this situation two sources are employed to compare measured and predicted normalised sound pressure levels. First a whirlpool bath was chosen, having two different pumps and being a relative complex source, and secondly a flushing cistern was investigated, having a time dependent excitation signal. Both sources can cause a considerable amount of disturbance in buildings.

The comparison of measured normalised sound pressure levels with predicted show, that the prognosis of sound pressure levels are possible and give relative good agreement. For the used building like transmission situation a dependence of source position for the resulting sound pressure levels was found, which could be encountered for real buildings by a correction term in the prediction model. For the prediction by the global power transfer function ($GLTF_n$), normalised sound pressure levels of the two sources are presented.

The report concludes with an overview of the restrictions for the characterisation of the structure-borne sound sources at the new laboratory. Also restrictions are given for the application of the global power transfer function ($GLTF_n$). The results of this project lead to additional tasks, which should be addressed in future studies.

With the newly developed reception plate laboratory for characterisation of structure-borne sound sources, in combination with the described prediction models, it is now possible to predict the sound pressure levels in buildings. With this the prediction models can be verified and, if necessary, improved. The comparison of predicted and measured sound pressure levels showed a good agreement. This demonstrates, that the objectives of this study where achieved.