Short report on the research project
Installation noise in lightweight construction

Research Initiative ”Zukunft Bau“ of the Federal Institute for Research on Building, Urban Affairs and Spatial Development
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Title

Noise transmission by technical installations in lightweight construction

Motive / Starting point

Since service equipment in buildings often causes noise that is perceived as particularly disturbing, it is subject to strict sound insulation requirements. While extensive experience is available for solid construction, there is currently only limited knowledge about installation noise in timber and lightweight construction. For this reason, the generation and transmission of noise related to lightweight multi-layered components was examined in more detail.

Subject of the research project

The investigations carried out were mainly measurement-based and performed in building acoustic test facilities adapted for this purpose. Due to the large variety of existing constructions, the measurements had to be carried out using representative installations and components as examples. For this purpose, a test set-up was used in which a standard wooden beam ceiling was excited on the upper side by a water installation. Then the resulting installation sound level was measured in the receiving room situated below the ceiling.

The investigation program comprised six different ceilings, including four wooden beam ceilings and, for comparison purposes, two solid ceilings. In addition to the standard installations customary in practice and represented by shower trays and floor-level shower areas, several structure-borne sound sources with a simplified structure served as excitation source. On the one hand, this had the advantage of lower manufacturing effort and, on the other hand, helped to interpret the measurement results due to the defined acoustic boundary conditions.

Besides the six examined ceilings, the investigations comprised over thirty different structure-borne sound sources, resulting in a comprehensive investigation program with almost one hundred and forty different measuring configurations. In addition to the determination of the resulting installation sound level, numerous other measurements were carried out which characterized the acoustics of the ceilings and installations investigated, and also provided the input data for the calculations carried out (e.g. source and input admittance, free vibration velocity and transmitted structure-borne sound power).

The most important results of the research project can be summarized as follows:

- The structure-borne sound power transmitted into the structure by the installation strongly depends on the ratio between the source admittance and the input admittance of the excited component. In contrast to solid ceilings, with an input admittance usually much smaller than the source admittance of conventional installations, the admittances of wooden beam ceilings are approximately of the same order. As a result, much more structure-borne noise is transmitted into the ceiling.

- In addition to admittance, the installation sound level is primarily determined by the structure-borne sound reduction index of the ceiling. Due to their multi-layered construction, wooden beam ceilings have a significantly higher structure-borne sound reduction index than solid ceilings with comparable airborne sound insulation. However, as considerably more structure-borne noise is transmitted into the ceiling, the resulting installation noise level in timber construction is usually still higher on balance.
- The usual models applied to describe the structure-borne sound excitation of building components refer to an alternating force directed perpendicularly to the component surface and acting as a point source. According to the investigations carried out, the simplified models can also be applied with sufficient accuracy in practice to structure-borne sound sources both with several contact points, and with linear or planar contact to the structure.
- If the parts of the ceiling construction having direct contact with the structure-borne sound source coincide (e.g. two ceilings with an identical floating screed), the installation sound level can be transferred easily and with good accuracy from one ceiling to the other using the normalized impact sound level.
- In order to be able to calculate the installation sound level in timber and lightweight construction in advance, a method was developed which is combining calculation and measurement. First, the structure-borne sound power transmitted into the ceiling by the installation is calculated in accordance with DIN EN 12354-5. Since the propagation of structure-borne noise in the building cannot be calculated, a measured transfer function, the above-mentioned structure-borne sound reduction index, is used instead. The accuracy of the method results in a standard deviation of approximately 3 dB, which is usually sufficient for sound insulation planning in practice.

Conclusion

With the research project the state of knowledge on the generation and transmission of installation noise in timber and lightweight construction was considerably enhanced. The metrological investigations carried out on different building installations and ceiling constructions contribute to a better understanding of the acoustic relationships and the interaction between the structure-borne sound source and the excited structure. In addition, for the first time it was possible to calculate installation noise in wooden and lightweight buildings under practically relevant conditions. Thus, all the objectives of the project could be achieved.

Basic data

Short title: Installation noise in lightweight construction
Scientist / Project management: Dr. Lutz Weber
Total cost: 166,174.00 €
Federal subsidy: 116,174.00 €
Project term: 24 months

Pictures / Drawings

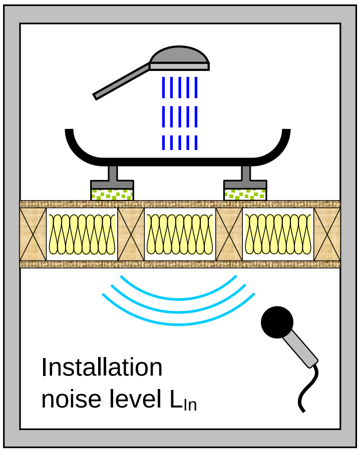

Fig. 1: Measurement setup to determine the installation noise level of water installations using a shower tray placed on an timber ceiling as example.

Fig. 2: Determination of the input admittance of a building component, using an electrodynamic vibration actuator (shaker) for excitation. A piezoelectric force transducer and two accelerometers (placed on the left and the right side of the excitation point) were used to measure the applied force and the resulting vibration velocity.

Fig. 3: Excitation of a completely mounted and tiled shower tray, using a tapping machine.

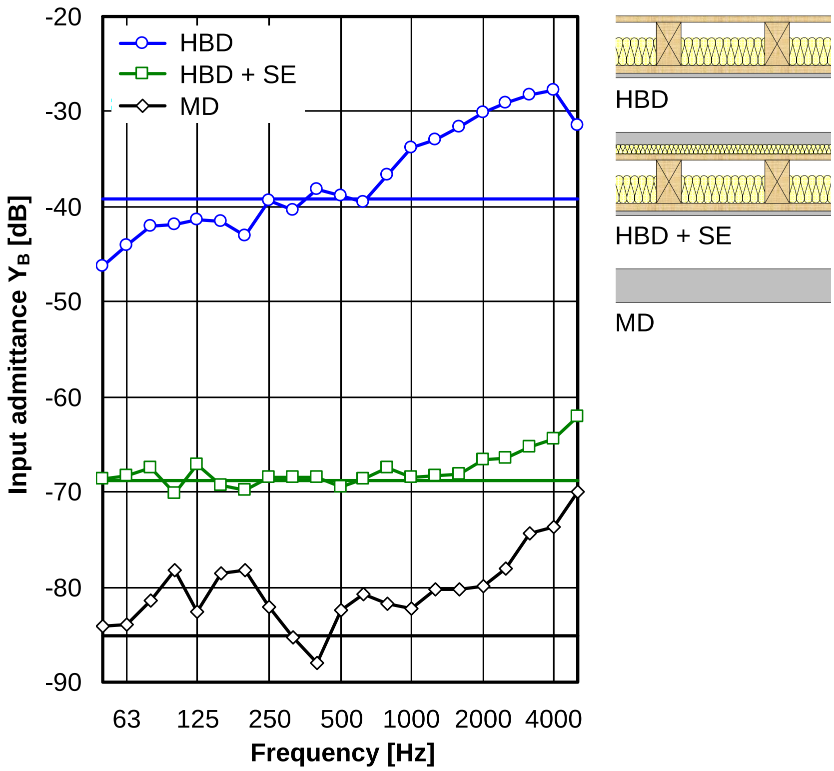

Fig. 4: Measured input admittance of a raw timber ceiling (HBD), a timber ceiling with floating floor (HBD + SE) and a solid ceiling (MD) compared to values calculated from the technical data of the components (horizontal lines of the same color).

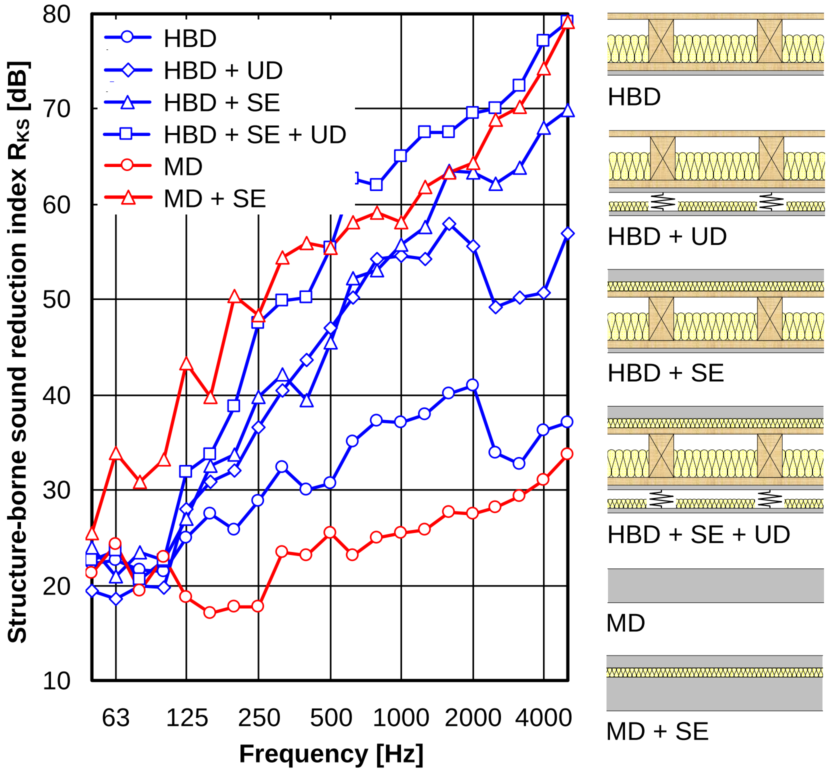

Fig. 5: Structure-borne sound insulation index of all investigated ceilings as a function of frequency.

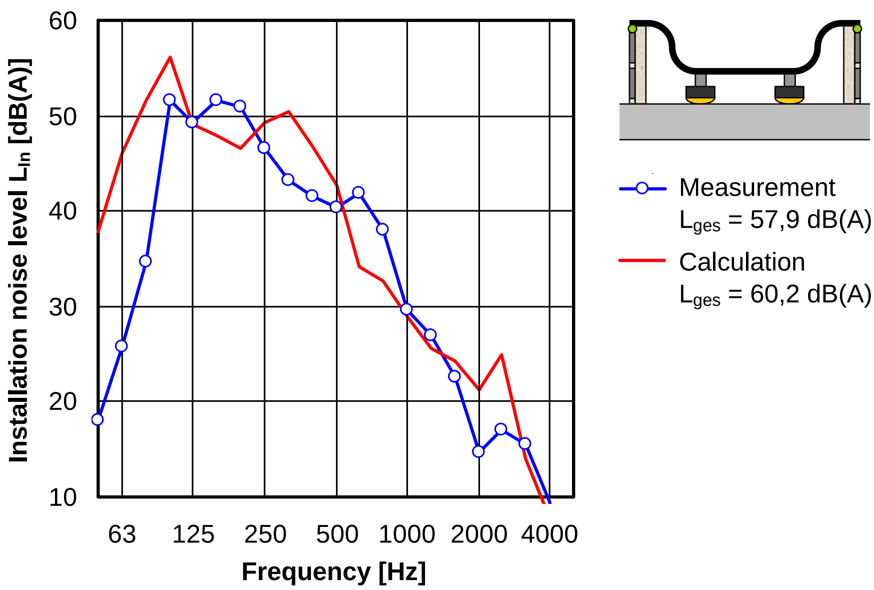

Fig. 6: Comparison between the measured and the calculated installation noise level of a shower tray. The excitation of the tray was performed by a tapping machine.