Effect of airborne sound on installation noise – Part 1: Basic investigations

M. Ebersold[1,2,3], L. Weber[1], S. Öhler[1], M. Blau[2]

[1] *Fraunhofer – IBP, 70569 Stuttgart, Germany,*
Email: mirco.ebersold@gmx.de, lutz.weber@ibp.fraunhofer.de, sven.oehler@ibp.fraunhofer.de
[2] *Fachhochschule OOW, 26121 Oldenburg, Germany, Email: matthias.blau@fh-oow.de*

[3]*now: Müller-BBM GmbH, 82152 Planegg, Germany, Email: Mirco.Ebersold@MuellerBBM.de*

Introduction

The noise excitation of buildings by service equipment takes place by both structure-borne and airborne sound. Mostly sound transmission is determined by the structure-borne portion. For some sources, however, the contribution of airborne sound can´t be neglected. A typical example is the EMPA-hammer [1], defined in the swiss standard SIA 181[2] as a standardized source for the simulation of user noise. Compared to other structure-borne sound sources, the amount of airborne sound emitted by the EMPA-hammer is very high. If airborne sound contributes substantially, conventional measures for noise reduction based on elastic isolation between source and building won´t work properly.

To analyse this problem, an experimental set-up (**Fig. 1**) was designed that allowed the separation of structure-borne and airborne sound. The set-up consisted of two parallel plates which where connected a) by an intermediate air gap and b) by an adjustable structure-borne sound bridge. The measurement set-up allowed the investigation of different acoustical effects under idealized conditions.

Experimental set-up for separating structure-borne sound from airborne sound

The experimental set-up was installed in a test rig acc. to DIN EN 15657-1[3] built up in the Fraunhofer-IBP in Stuttgart, Germany.

The set-up consisted of a source plate and a receiving plate adjusted parallel to each other. The source plate (0,90 m x 0,65 m) was hanging down from the ceiling using four cords attached to the edges of the plate. It was excited by means of a shaker and transmitted airborne and structure-borne sound into the receiving plate. During the investigations two source plates of different material (steel, d = 2 mm and chipboard, d = 10 mm) were used.

The receiving structure was a concrete plate resting on an elastic support. The elastic bedding of the receiving plate allowed determining the transmitted sound power directly from the mean velocity on the plate.

Source and receiving plate were connected by an adjustable structure-borne sound bridge. After removing the sound bridge only airborne sound was left so that the airborne and structure-borne part of sound transport could be separated.

The set-up allowed variations of the geometrical conditions such as distance between the plates, all-side encasing of the gap between the plates and division of the gap by intermediate partitions.

Furthermore it was possible to investigate the influence of acoustic measures like damping of the gap by mineral wool or damping of the source plate by a bitumen layer.

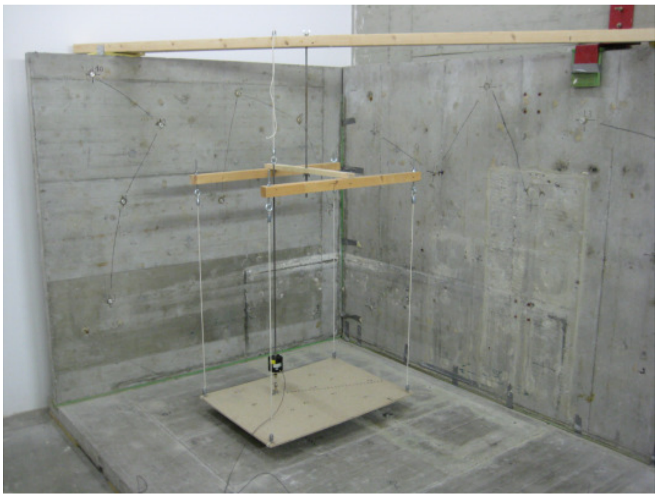

Figure 1: Simplified experimental set-up in a test rig acc. to DIN EN 15657-1 built up in the Fraunhofer-IBP, Stuttgart.

Variation of the distance between source plate and receiving plate

To investigate the amount of structure-borne and airborne sound the distance between the two plates was varied between 2 and 12 cm. It was measured how the mean velocity on the receiving plate changes depending on the distance between source plate and receiving plate. To compare structure-borne and airborne sound, in one case the two plates where completely decoupled from each other. In the other case the plates were connected by the structure-borne sound bridge.

The results showed that the velocity level at nearly all frequencies is strongly decreasing when the distance between the plates is increased. On the other hand the distance between the plates has no visible effect on the excitation of the receiving plate if the structure-borne sound bridge is built in.

Encasing of the gap between the plates

In most measurements the gap between the plates was open. In the following measurements the gap was encased on all sides by partitions made from chipboards. To investigate the effect of encasing on the excitation of the receiving plate the measurements were carried out for different distances between the plates with and without the encasing.

As can be seen from **Fig. 2** the encasing of the gap has a large effect on the excitation of the receiving plate. In the left as well as in the right part of the diagram there is a clearly visible rise of the velocity level at 125, 160 and 250 Hz if the gap is sealed.

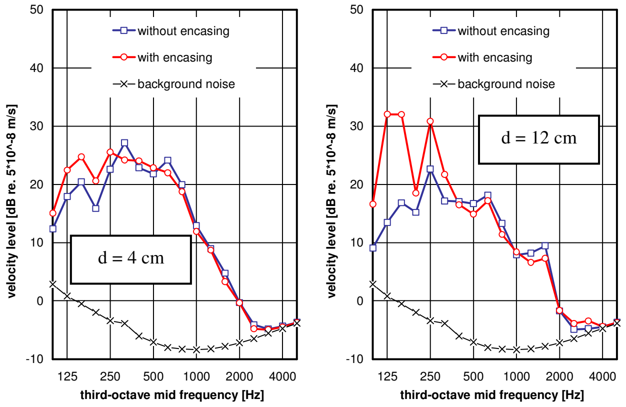

Figure 2: Mean velocity level on the receiving plate for two different distances between the plates. Measurement without structure-borne sound bridge but with and without encasing of the gap between the plates. Left: d = 4 cm distance between the plates. Right: d =12 cm distance between the plates.

The large increase of the velocity level at 125 and 160 Hz can be explained with a stiffening of the air layer between the plates. The increase at 250 Hz is due to natural resonances of the air inside of the gap that occur if the distance between the plates is increased. In [4] the natural resonances were identified by scanning the sound field in the gap. The first resonance was at 250 Hz.

Damping of the air inside the gap

Another experiment in order to investigate the influence of the airborne sound compared to the structure-borne contribution was to compare airborne sound transport with and without damping of the gap. The damping was realized by means of a holohedral layer of mineral wool (Isover Akustik TP 1, thickness: 10 cm).

Fig. 3 shows the mean velocity level on the receiving plate for various modifications of the experimental set-up (with and without encasing of the gap, damping of the gap and structure-borne sound bridge). All measurements were performed with 10 cm distance between the plates. It is obvious that airborne sound transport is determining the excitation at 125, 160 and 250 Hz if the gap between the plates is encased. This holds true even in the presence of a structure-borne sound bridge. At higher frequencies the transmission of structure-borne sound is determining the excitation of the receiving plate.

The damping of the gap with mineral wool has a large effect on the excitation by airborne-sound. The use of mineral wool as a porous absorber reduces the excitation especially at the natural resonance of the gap at 250 Hz. This underlines that the excitation in this frequency band is mainly determined by airborne sound.

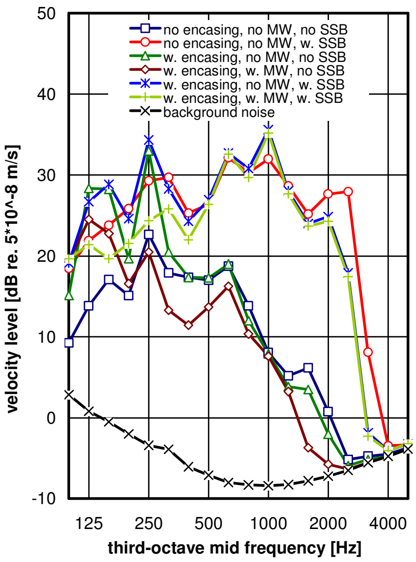

Figure 3: Mean velocity level on the receiving plate for various modifications of the experimental set-up. The distance between the source plate (here: chipboard) and the receiving plate was always 10 cm. Short cuts: MW = mineral wool, SSB = structure-borne sound bridge.

Conclusion

Systematical variation of the sound propagation conditions gave deeper insight into the acoustic effects occuring in the nearfield between the source plate and the receiving plate. The investigations showed that the contribution of airborne sound can strongly affect overall sound transport, especially if the gap between source plate and receiving plate is encased. The intensity of airborne sound transmission strongly depends on the acoustic conditions inside of the gap (amount of damping).

Transferred to real building situations the described effects can similarly take place and can lead to high noise levels in adjoining rooms. This for instance can occur when using the EMPA-hammer for exciting sanitary installations.

References

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[4] Ebersold, M.: Trennung von Körperschall- und Luftschallübertragung bei haustechnischen Anlagen. Diplomarbeit, IBP-Stuttgart, FH Oldenburg, 2008.