How to detect sound bridges

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Introduction

Finding sound bridges - or more generally spoken - finding sound sources and transmission paths, is one of the basic tasks in acoustical engineering. In building acoustics, multi-layer constructions like double walls and floating floors are among the most often used elements, and one single sound bridge can destroy their acoustical advantage and all the extra expenses compared with analogical single layer constructions.

In this paper 'sound bridges' mean any structural connection between a structure borne sound source and a receiving structure or between two structures. Examples are sound bridges between floating floors and the bare floor or flanking wall, the sound bridges between the leaves of double walls, the feet of machines, the clamps of vibrating pipes and so on.

First question: Are there any sound bridges at all?

If one starts seeking for sound bridges, it should be ensured, that the lack of sound insulation is not caused by other effects with similar symptoms, f.g a strange behaving bare floor in ***the case of floating*** floors. Figures 1 and 2 show as an example, how sound bridges in floating floors normally effect the impact sound pressure level of a floor [1]. If the field situation is unknown, as usual, the knowledge of an acoustic expert is needed for the right interpretation of measured results.

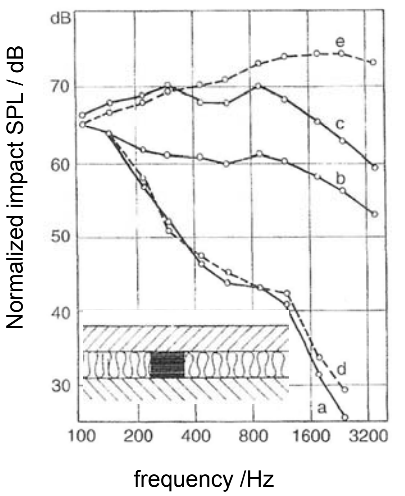

Figure 1: Normalized impact sound pressure level of a bare (e) floor with no (a), 1 (b) or 10 (c) sound bridges [1]

Second question: Where are the sound bridges?

Method of hammering and listening

To find sound bridges along floor edges, HALBE [2] proposes to hit the floor with a plastic hammer, starting from the center of the floor (assuming no sound bridges there) and moving toward the edges. A sound bridge is supposed to change the booming hammer sound into 'clacking' when approaching. As reported the method is not aleays successful.

Method of velocity measurements

In 1979 MECHEL and GIEßELMANN presented different structure borne sound measurements to detect the position of sound bridges. A promising method is to excite the floating floor with a (self-constructed) 1-hammer-tapping-machine and to measure the acceleration level of the floor under test. Hammer and pickup are moved simultaneously across the floor, keeping a constanf distance of about 5 cm between each other. Close to a sound bridge the acceleration level will decrease by 15 to 20 dB. As the catchment area of sound bridges is shown to be about half a bendingwavelength, low-frequency bandpass filtering (125 Hz octave band e.g.) increases the sensitivity of the method.

Method of direction discrimination by the human ears

With our ears we can directly hear where a sound comes from, even in reverberant sound fields. Figure 4 shows a tool which allows to listen 'stereo' into a structure to detect the direction of incoming structure borne sound signals (Pat. DE 196 40 605 C2). A left-right canal interchange switch improves the localisation ability considerably. In principle, the tool allows to locate all kinds of sources like installation noise, noise in pipe systems, cracking heating systems and so on. Moreover different structureborne sound transmission paths can be directly compared by fixing the pickups to them and listen, where the sound mainly comes from. Passive transmission paths like sound bridges need a sound excitation somewhere at the opposite end of the path (figure 5).

Using the heat conduction of sound bridges

Sound bridges conduct heat or block heat transfer (depending on the material) and can thus be made visible by special thermographic methods (Pat. DE 196 44 097 C1). Calculaion and measurements by GIANNAKOU [4] showed good results for concrete floating floors (figure 6) and all kinds of lightweight constructions like double leaf gypsum-board walls and the like. Sound bridges in heavyweight double leaf masonry probably cannot be detected because of too small temperature differences across the wall surface (<<1°C).

Method of structureborne sound intensity measurements

In 1987 MAYSENHÖLDER et al. proposed to localize sound sources (or sound transmitting sound bridges) by structureborne sound intensity measurements [5]. Theoretically the intersection point of two intensity directions yields the exact position of the source. In practice reflections, nearfields, inhomogeneities and bulding element resonances can affect the results, which is proposed to overcome by an increased number of measurements and by suitable frequency and spatial averaging including a reliability weighting of the different measuring positions. Figure 7 shows results for a 17,5/11,5 cm lime-sand brick stone double wall.

Other methods

Inspired by pulse tracing in airborne sound one could consider delaytime measurements with structureborne sound pulses a good method to find sound bridges. Two facts are opposed to that: Bending wave pulses are deformed by dispersion while propagating. And the duration of a hammer hit can be of the same order of ma gnitude as the propagation time difference between direct sound and first reflection.

Conclusions

There are many different methods 'on the market', which approach the the problem either directly (just hear or see) or by measurement. All methods are subject to the same physical restrictions: reflections lead to non-existent virtual sources, other unknown effects look like sound bridges but aren't, and a high number or large extension of the sound bridges as well as additional airborne sound transmission can confuse the situation. Therefore the knowledge and experience of an acoustic expert will always be indispensable.

References

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2) Halbe, Chr.: Schallbrücken von schwimmenden Estrichen mit hartem Bodenbelag ... Fortschritte der Akustik, DAGA 1995

3) Gießelmann, K., Mechel, F.: Schalltechnische Mängelsuche in ausgeführten Bauten. Bericht des Fraunhofer-Instituts für Bauphysik 1979

4) Giannakou, E.: Lokalisierung von Schallbrücken mit Hilfe der Thermografie. Diplomarbeit, 1997. Betreuer W. Scholl, K. Sedlbauer, S.R. Mehra

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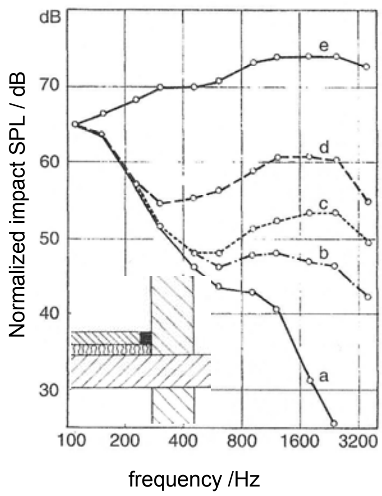

Figure 2: Sound bridges between floating floor and wall
a: no bridge
b: bridge of 0,1m length
c: 0,5m length
d: 2,5m length
e: bare floor

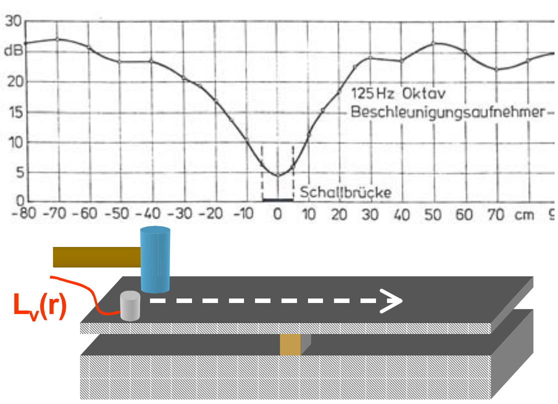

Figure 3: Sound bridge detection by acceleration measurenment acc. to [3].

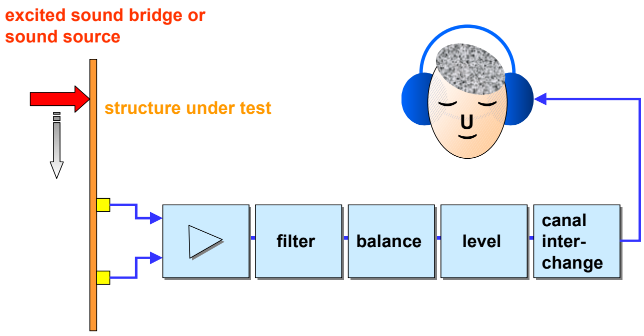

Figure 4: Two channel transmission of structureborne sound to a human listener

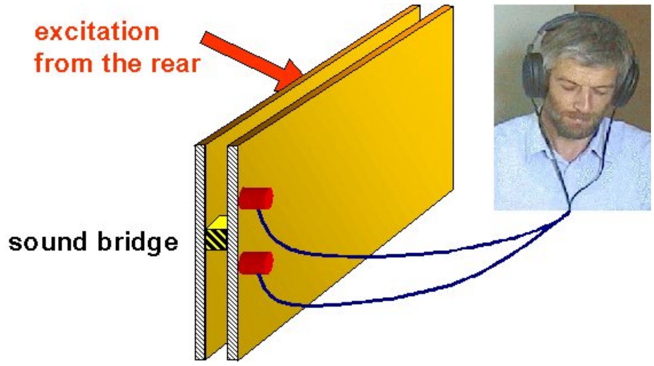

Figure 5: localising sound bridges with the stereo hearing device

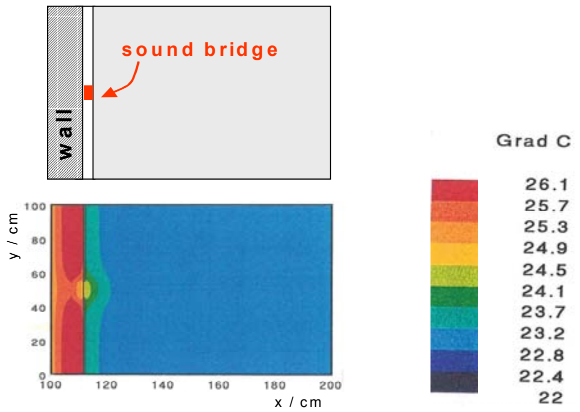

Figure 6: Thermografy of a sound bridge between floatong floor and heavy solid wall, top view [4]

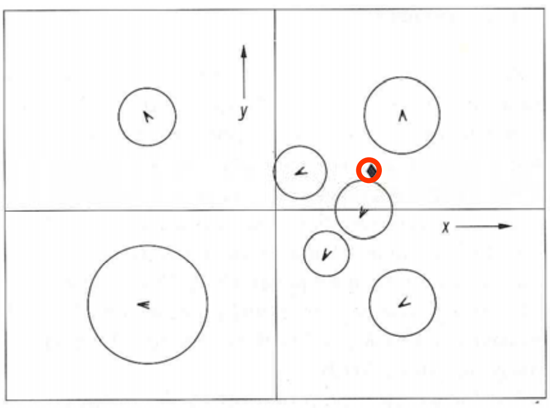

Figure 7: Aspect of a double wall with a sound bridge [5]. Arrows: Intensity, thin circles: vibration levels, thick circle: sound bridge