CAN THE IMPACT SOUND IMPROVEMENT OF FLOOR COVERINGS BE MEASURED ON A WOODEN MOCK UP INSTEAD OF A TIMBER JOIST FLOOR?

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ABSTRACT

The new ISO/CD 140-11 treats the laboratory measurement of the impact sound pressure level improvement of floor coverings on timber joist floors. To avoid the need of having an entire wooden reference floor available, it was proposed by Hans Jonasson to use a wooden mock up instead, which is put on top of the ISO 140-8 reference concrete floor to simulate the input impedance of a wooden floor. The Physikalisch-Technische Bundesanstalt (PTB) participated in a corresponding round robin test carried out by the Swedish National Testing and Research Institute in 2001. This paper presents additional investigations by PTB, such as mock up feet material and a comparison between mock up and 'real' wooden floor results.

INTRODUCTION

It is well known, that laboratory measurements of the impact sound reduction improvement of floor coverings on solid concrete floors yield much better results than can be found for the same floor coverings on lightweight basic structures such as timber joist floors. Therefore a new part of the ISO 140 series was created to regulate the laboratory measurement of the impact sound reduction improvement on lightweight floors [1]. To carry out the measurement it is necessary to build up one of the timber joist floors which are proposed as reference floor constructions in the standard. If a laboratory is equipped only with one test facility for floors, it is very ineffective and costly to make measurements of the impact sound reduction improvement on heavy and lightweight floors alternately. This problem is avoided by the proposal of Hans Jonasson to keep the standard basic concrete floor acc. to ISO 140-8 and just to add a wooden mock up on top of the concrete floor, to simulate a timber joist floor. To test the feasibility of this method a round robin test was carried out in 2001 by the Swedish National Testing and Research Institute with participants from Sweden, Denmark, Norway, Iceland and Finland. The results are reported in [2]. Austria and PTB Germany joined in a little bit later and their results are not yet included in the report. The regular test program comprised impact sound reduction improvement measurements of two different carpets and a 'parquet' which was simulated by a layer of 22 mm chipboard on 12 mm soft wood fibre board. To check the influence of the basic structure on the impact sound improvement, the tests had to be carried out on the concrete bare floor, on the simple form of the mock up (called 'top floor'), on the top floor plus additional layer of chipboard and on the top floor plus particle board on 36 mm soft wood fibre board. Details can be taken from table 1, see basic structures No. 1 to 4. The top floor was supposed to be composed of 22 mm chipboards (2600 mm x 2000 mm with given density and stiffness) on spruce feet (length

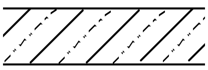
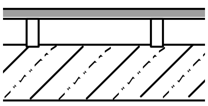
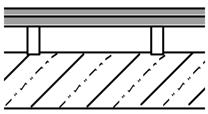
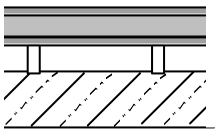
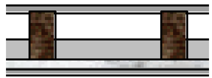
193 mm, width 45 mm x 45 mm) with the grain parallel to the chipboard and arranged on a grid spaced 600 mm x 600 mm. Figure 1 shows the top floor before fixing it to the concrete floor.

Figure 1. Top floor waiting for use

Figure 2. Small top floor for extra tests

As many hobbyists know, the characteristics of wood are widely scattering. E.g. no chipboards of the required density and Young's modulus were available in Germany and thus had to be replaced at PTB by medium dense fibre boards (MDF). Some extra tests were made at PTB with a much smaller top floor (see figure 2) to investigate the influence of foot material and direction of the grain as well as the differences caused by the fact that one hammer of the tapping machine might exactly hit one of the top floor feet. Last but not least a dry floating floor (i.e. gypsum fibre boards instead of a concrete slab on the insulation layer) was investigated additionally and all impact sound improvement measurements were repeated on the timber joist reference floor No. 1 of ISO/CD 140-11 for comparison. A survey of the test program at PTB is shown in table 1. In the following the results of the PTB measurements are reported.

Table 1. Survey of the test objects at PTB

Basic structures				
1	2	3	4	5
				
140 mm concrete	22 mm particle board 195 mm spruce feet 140 mm concrete	22 m particle board, 22 mm particle board 195 mm spruce feet 140 mm concrete	22 m particle board 36 mm soft wood fibre 22 mm particle board 195 mm spruce feet 140 mm concrete	timber joist floor acc. to ISO 140-11 (CD)
Tested floor coverings				
carpet 1	carpet 1	carpet 1	carpet 1	carpet 1
carpet 2	carpet 2	carpet 2	carpet 2	carpet 2
parquet floor: 22 mm chipboard 12 mm soft wood fibre	parquet floor: 22 mm chipboard 12 mm soft wood fibre	parquet floor: 22 mm chipboard 12 mm soft wood fibre	parquet floor: 22 mm chipboard 12 mm soft wood fibre	parquet floor: 22 mm chipboard 12 mm soft wood fibre
X	dry floating floor: 20 mm gypsum fibre board 10 mm mineral wool	X	X	dry floating floor: 20 mm gypsum fibre board 10 mm mineral wool

INFLUENCE OF THE TOP FLOOR FOOT MATERIAL

As spruce is not a very well defined material, a small top floor (1 m x 1 m, four feet at the corners, one in the center, corresponding to a 60 cm x 60 cm grid) was built and three different types of feet tested: (1) spruce with horizontally oriented grain like the timber joists, (2) spruce with vertically oriented grain and (3) copper-beech with vertical grain. Figure 3 shows as an example the impact sound improvement of the parquet on the top floor with the above mentioned feet. Obviously there are differences up to about 10 dB, but the origin is not clear as there are other reasons present for scattering, such as the position of the hammers of the tapping machine with respect to the top floor feet position.

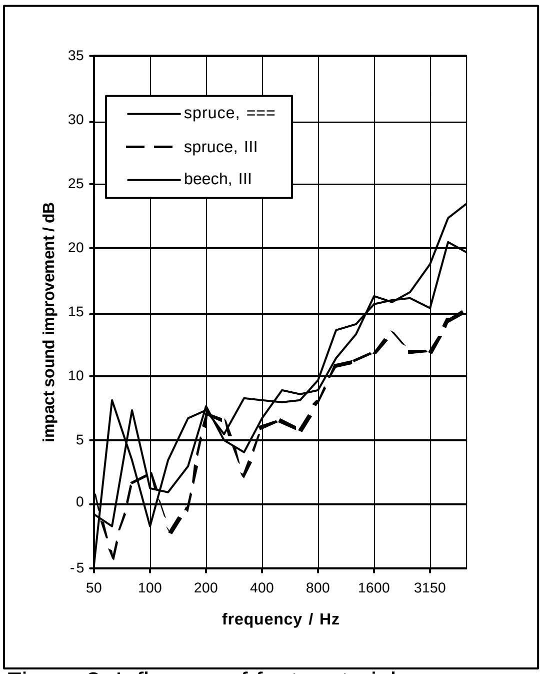


Figure 3. Influence of foot material

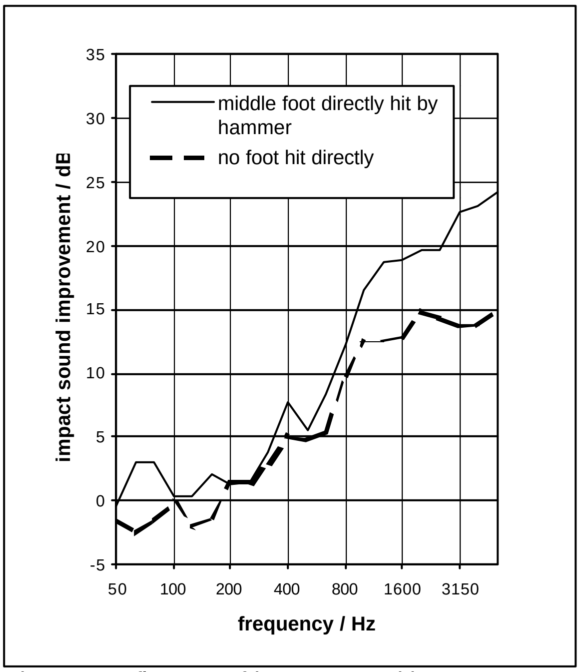


Figure 4. Influence of hammer position

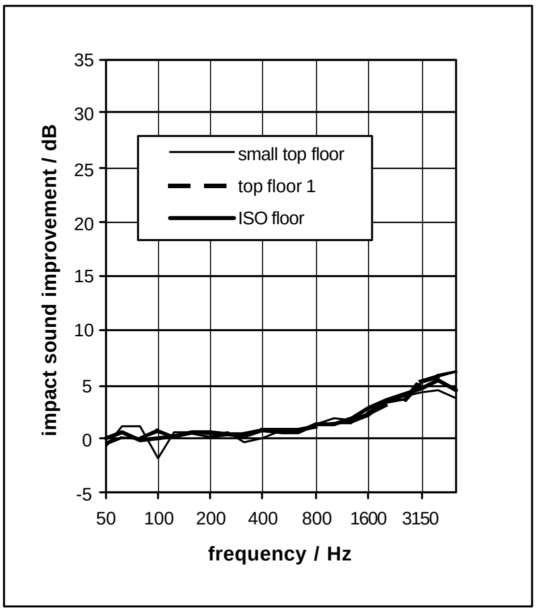
INFLUENCE OF THE HAMMER POSITION OF THE TAPPING MACHINE

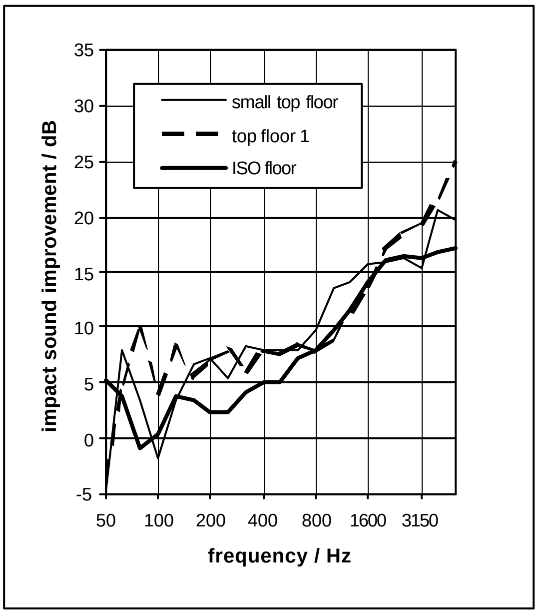
It can be expected that there is an influence on the impact sound reduction improvement, depending on whether one of the hammers of the tapping machine exactly hits a foot position of the top floor. Figure 4 gives an example of this influence. There is a tendency towards higher values of impact sound improvement at higher frequencies, when a hammer hits a foot position. This was found with different foot material and floor coverings.

INFLUENCE OF THE TYPE OF BASIC CONSTRUCTION

As there are different kinds of lightweight bare floors and different kinds of wooden joist floors in particular, it has to be asked, whether there is an impact sound improvement of floor coverings on lightweight floors at all. It can be argued that the mechanical input impedance of different lightweight floors differs much and is not always big compared with the impedance of the floor covering so that there is a strong interaction between basic floor and floor covering. Furthermore there are floor coverings, where the sound reduction improvement may be affected, when only a small area and not the entire area of the test room floor is used. This is the case with the proposed mock up for example. Floor coverings of type mentioned are floating floors or maybe parquet floors. Important effects are the change of the radiation efficiency and the mass charge of the basic floor by the floor covering. Figure 5 shows a comparison of the impact sound improvement of different floor coverings when applied to the small top floor (1 m²), the 'full' top floor (5,2 m²) and the reference floor No.1 of ISO/CD 140-11 (20 m²), simply called

'ISO floor'. Figure 6 shows the behaviour of the parquet floor on the basic structures No. 2, 3, and 4 (c.f. table 1). Obviously for carpet 1 with a rather low impact sound improvement the basic test floor is not of much importance. The same holds true for the better carpet up to 800 Hz. The influence of the basic floor seems to increase at higher frequencies where the improvement exceeds 20 dB. The parquet floor and the dry floating floor show a much bigger influence of the basic structure. The deviations occur within the whole frequency range. Changing the test floor area from 1 to 20 m² results in a similar deviation of the impact sound improvement as changing the type of basic floor constructions (No. 2, 3, 4 in table 1). In the present examples of the parquet and floating floors, it seems that the 20-m²-ISO floor yields lower improvement values than the smaller mock ups, and that the basic floors with higher impact sound insulation yield the lower improvement values.





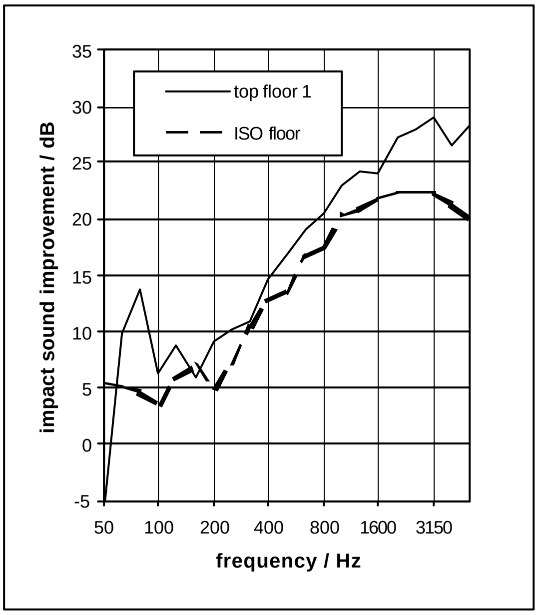


Figure 5.
Influence of the basic structure on impact sound improvement. Here: test arrangements of different size.
Small top floor (1 m²) see figure 2.
Top floor 1 corresponds to the basic structure 2 in table 1 (5.2 m²).
ISO floor is the reference floor No.1 in ISO/CD 140-11 (20 m²).

Top left: carpet 1
Top right: parquet floor
Right: dry floating floor

INFLUENCE OF BY-PASS TRANSMISSION

During the tests it became obvious that there is another effect which strongly influences the measured values of the impact sound reduction improvement mainly at higher frequencies, where the improvement achieves high values: by-pass sound transmission. The airborne sound power of a standard tapping machine was measures in a reverberation room when hammering on different floors (0.45 m² and 3.5 m² of floating floor and 4 m² MDF board). The results roughly were as follows: The emitted airborne sound power is constant between 160 and 1600 Hz for the MDF board and constant up to 3150 Hz for the dry floating floor. It is mainly independent from the floor area, which means that the point of excitation radiates most of the sound power.

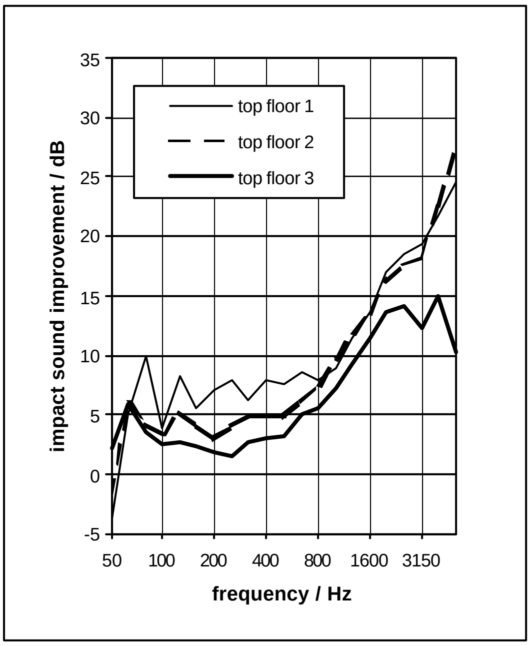


Figure 6.
Influence of the basic structure on impact sound improvement of the parquet floor.
Here: basic structures of different type.

Top floor 1 = basic structure 2 in table 1
Top floor 2 = basic structure 3 in table 1
Top floor 3 = basic structure 4 in table 1

The sound power level per third octave band is between 88 and 93 dB in the 'constant' frequency range and less outside. Figure 7 shows the comparison of the normalised impact sound pressure level under the tested floor (Ln), and the airborne sound pressure level (Lair) caused in the receiving room by transmission of the airborne sound from the standard tapping machine. Lair is calculated for a test facility with two rooms above each other, reverberation time 1,5 s in both rooms, 20 m² separating floor of 14 cm concrete, and an airborne sound power of the tapping machine as measured (about 90 dB per third octave band). Ln was taken from a measurement of the parquet on the top floor No. 4. The fact that the impact sound pressure level Ln does not exceed the airborne sound pressure level from the tapping machine, transmitted through the floor under test, shows very clearly, that reliable improvement measurements cannot be achieved without special measures to reduce the airborne sound of the tapping machine and to increase the sound insulation of the basic structure. This is a special problem of the mock ups with reduced size, when the floor covering is very noisy on the one hand but reduces effectively the impact sound transmission by reflection on the other hand as is the case with parquet or floating floors. The problem is less severe, when testing floating floors e.g. which cover the total floor area, as they act as an acoustic lining at the same time, which improves the sound reduction index of the floor under test considerably.

OTHER INFLUENCES

Two other influences on the impact sound reduction improvement measurement should be mentioned. Firstly there is an unexpectedly strong influence of the cleanness of the surfaces on the source strength of the tapping machine. A repetition of the impact sound pressure level of the empty top floor showed deviations from the original values of up to 6 dB at medium and high frequencies, which disappeared after thoroughly cleaning the floor surface (Figure 8). Secondly the feet of the mock up came off the concrete floor after some measurements. This resulted in a different structure borne sound spectrum on the top floor, when exciting the concrete basic floor. This has not been investigated yet in detail.

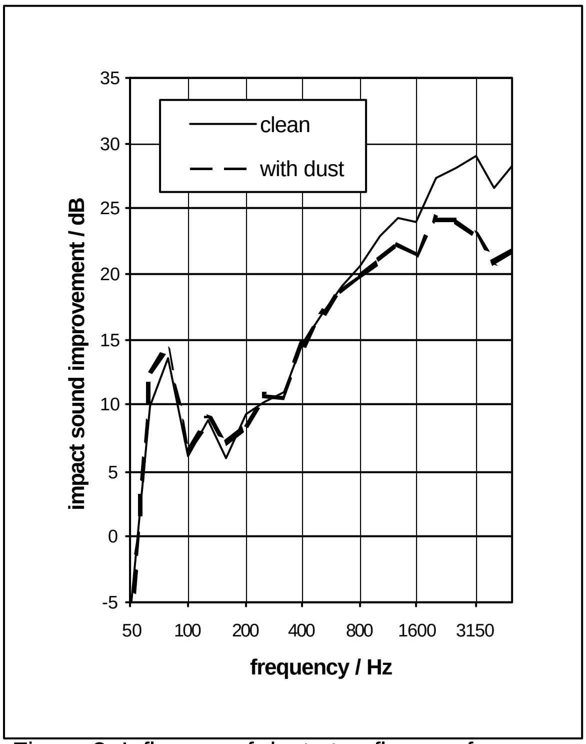


Figure 8. Influence of dusty top floor surface

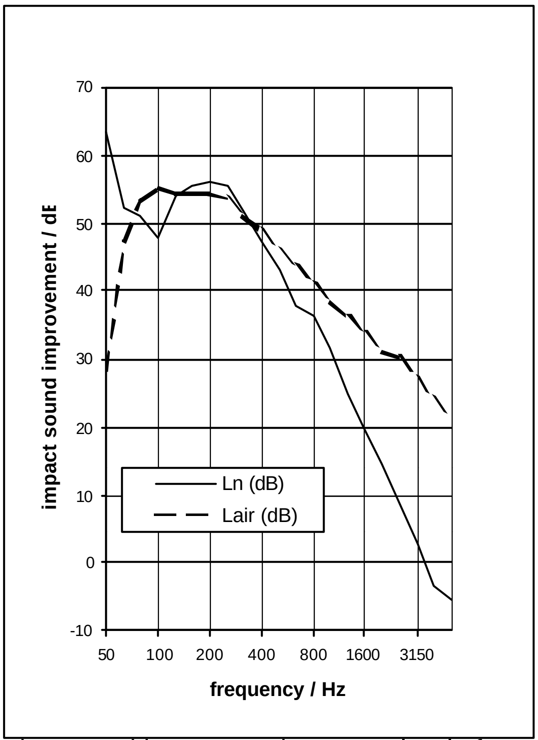


Figure 7. Airborne sound pressure level of the tapping machine in the room below the tested floor, compared with the normalised impact sound pressure level (parquet on basic structure No.4 - see table 1)

CONCLUSIONS

The replacement of timber joist floors as basic structures for impact sound improvement measurements on lightweight floors by a wooden mock up on the standard concrete floor acc. to ISO 140-8 seems a cheap and easy alternative, which works well with locally acting floor coverings such as carpets. For parquets and floating floors bigger deviations have to be expected. But this is not a particular problem of a mock up of reduced size but a general problem of different floor types which occur in laboratories and even more in reality. With the mock up and it's limited capacity of airborne sound insulation, by-pass transmission should be watched carefully. The long-term stability of the mock up and its fastening has to be investigated thoroughly.

BIBLIOGRAPHY

[1] ISO/CD 140-11:2001

[2] Kartous, M., Jonasson, H. G.: A Simplified Method to Determine Impact Sound Improvement on Light-Weight Floors. Nordtest Project 1544-01, SP Rapport 2001:37, Acoustics, Borås 2001.