A simplified measurement method for the determination of impact sound reduction

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Introduction

Impact sound reduction is the main quantity for describing the acoustic behaviour of floor coverings. Its determination is standardised in ISO 140-8 [4] and ISO 140-11 [5] and requires the use of a special test facility. This facility consists of two rooms of about 50 m^3 each, separated by a 16 cm concrete slab or a special timber joist floor. Manufacturers of floor coverings see the advantage of having their own test facilities but the investment often cannot be afforded by the small- and medium-sized enterprises. Therefore, a research project was started with the aim to reduce the effort for the determination of the impact sound reduction. The project is funded by the German Federation of Industrial Research Associations "Otto von Guericke" Inc. (AiF) and has a duration of 2.5 years. The research work is carried out at Physikalisch-Technische Bundesanstalt (PTB) and at the Research Institute of Leather and Plastic Sheeting gGmbH (FiLK).

Existing short test method

The starting point of the investigation is a known short test method TGL [1], [2]. The maximum acceleration of a 500g hammer is measured when it falls from a height of 4 cm on a soft layer. From the maximum acceleration, the rated value of the reduction of transmitted impact noise is calculated directly.

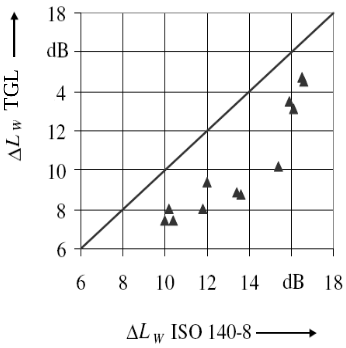

Figure 1: Difference of ΔL_W [dB], concrete: TGL [2] vs. ISO procedure [4]

Initially it was examined as to whether this procedure, perhaps with small adaptations, could also be applied today. In an AiF pre-project [3] it appeared that the results of the TGL procedure are systematically about 3 dB smaller than those of the ISO procedure (see figure 1). Based on this situation, the TGL procedure was analysed. The assumption of an impulseshape from which a general spectrum was derived (for the reduction of transmitted impact noise) turned out to be essential. Moreover, a typical value of the size of the impulse is used which was determined from measurements [1] with floor coverings available at that time. An adaptation to today's layers would not lead to the goal, because the measuring procedure would not be applicable without necessary adjustments at regular intervals in comparison to the floor coverings currently placed on the market. A project task is the elaboration of a procedure which can be introduced as a work item proposal at ISO. This aim is not accessible by the (perpetual) modification of the TGL standard.

New compact measurement set-up - COMET

Within the scope, a compact measurement set-up is developed which delivers rated values [6] of the reduction of transmitted impact noise. The results should correspond on average to those of the ISO procedure ISO 140-8 [4] and respectively, ISO 140-11 [5], and the realisation of the measurement should be easy. In the constructional systems, two floors should be used by analogy with the ISO procedure: a heavyweight floor and a lightweight floor. The required applicability is the operation with soft floor coverings. Parquet or laminate is to be examined.

The first construction consists of a concrete slab of the dimension 1.2 m x 0.8 m x 0.2 m which lies in a steel rack in the Euro format. Between stilts and concrete slab, an elastic material is introduced which decouples the concrete slab. The system resonance lies at f = 27 Hz and therefore below the interesting frequency range of building acoustics (see figure 2).

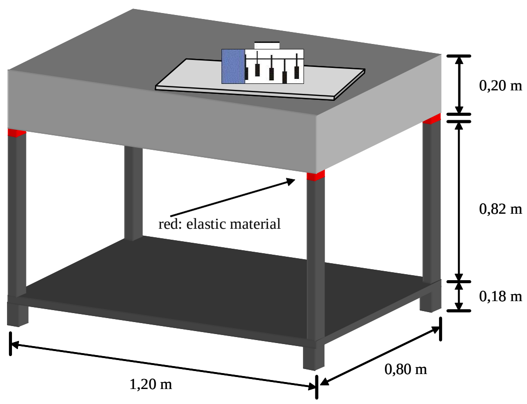

Figure 2: Construction of COMET, concrete floor

The second construction consists of a timber joist floor of the dimension 1.2 m x 0.8 m x 0.2 m which lies in a steel rack in the Euro format (see figure 3). Between stilts and

concrete slab, an elastic material is introduced which decouples the timber floor with a resonance at $f = 22$ Hz. It is thus below the interesting frequency range of building acoustics. The construction is related to the timber joist floor (type 1) described in ISO 140-11. The only difference in dimension is the distance between the two timber joists: instead of 62.5 cm they have a gap of 68 cm.
The measurements are carried out with a 1/3 octave band analyser. For the excitation, an ISO tapping machine is used. In analogy to the ISO procedures, two tests are performed, once with and once without the floor covering on the concrete. At the bottom of the concrete slab, the appearing oscillations are measured with six accelerometers and the impact noise reduction has to be averaged over those receiver points. The figures 4, 5, 7 and 8 show the results of this step.

The positions of the receivers are randomly distributed and not arranged in symmetric lines. From two measurements (with / without layer) one calculates the impact noise reduction:

$$\Delta L = L_{an,0} - L_{an} \tag{1}$$

where $L_{an,0}$ is the averaged acceleration level at the bottom of the concrete slab without covering and L_{an} the same measured quantity with covering.

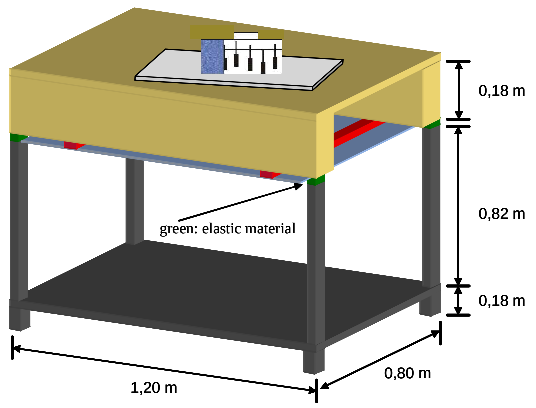

Figure 3: Construction of COMET, timber floor

Afterwards ΔL can be rated according to ISO 717-2 [6]. The result is the rated reduction of transmitted impact noise ΔL_W in dB. Figures 6 and 9 show the results of this step. It is possible to generate other rated values from ΔL. This is an advantage compared to the TGL procedure with which only ΔL_W could be determined.

Results – heavyweight floor

The results of the new compact method are compared to those of the ISO procedure. Figures 4 and 5 show two by two measurements each of ΔL.

The colours stand for different coverings. The deeper colour is correlated with the compact - the lighter with the ISO procedure: black refers to PVC, green to carpet, blue to linoleum and red to laminate.

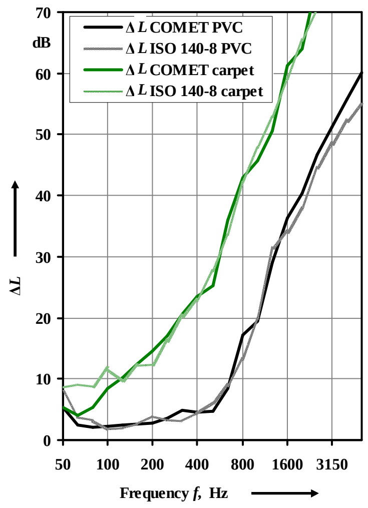

Figure 4: Impact noise reduction ΔL [dB], concrete: COMET vs. ISO procedure

It is to be acknowledged that spectral divergences hardly exist between the compact and ISO procedure for PVC, carpet and linoleum coverings due to their local elastic effect. The curves nearly fit. Laminate reveals larger discrepancies due to its plate-like effect. The compact procedure delivers lower values compared to ISO in this case.

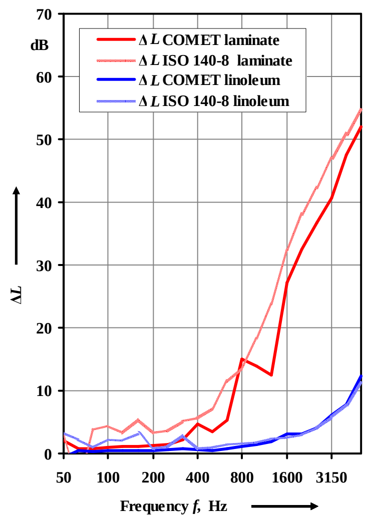

Figure 5: Impact noise reduction ΔL [dB], concrete: COMET vs. ISO procedure

Figure 6 shows the results of impact noise reduction ΔL_W determined by the compact and ISO procedure. Altogether, 25 PVC, 7 carpet, one laminate and one linoleum floor coverings were tested. The diagram shows that no systematic deviation is visible between the two measuring procedures. The mean squared deviation *msd*

$$msd = \sqrt{\frac{1}{(N-1)} * \sum_{i,j=1}^{N} (\Delta L_{w,i,Comet} - \Delta L_{w,j,ISO})^2} \tag{2}$$

of all 34 measurements is 0.8 dB.

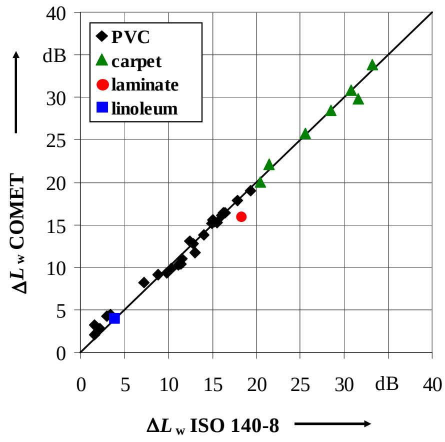

Figure 6: Deviation of ΔL_w [dB], concrete: COMET vs. ISO procedure

Table 1 shows the maximum deviation Δ_{max}.

$$\Delta_{\max} = \left| \Delta L_w, compact - \Delta L_w, ISO \right|_{\max} \tag{3}$$

The largest deviation is yielded for the laminate due to the different spectral results (figure 5). Nevertheless, all deviations are relatively small in view of the usual uncertainties in building acoustics which often reach values of several dB.

Floor covering	Δmax
PVC	1.6
Carpet	1.8
Laminate	2.4
Linoleum	0.1

Table 1: Maximum deviation Δ_{max} , concrete

Results – lightweight floor

The measured data is presented in the same way as for the heavyweight floor. Figures 7 and 8 show two pairs of measurements: PVC / carpet and laminate / linoleum floor covering. The compact procedure delivers lower values for the PVC / laminate and larger ones for the carpet / linoleum compared to ISO in these cases.

A comparison between the impact noise reductions determined by the compact and the ISO procedure is shown in figure 9. Altogether, 13 PVC, 7 carpet, one laminate and one linoleum floor coverings were tested.

Table 2 shows the maximum deviation Δ_{max}.

Floor covering	Δmax
PVC	1.7
Carpet	4.4
Laminate	2.8
Linoleum	0.7

Table 2: Maximum deviation Δ_{max} , timber

They reach values of up to 4.4 dB. The discrepancies are to be investigated in future.

There is no systematic deviation visible between the results. The mean squared deviation turns out to be 1.9 dB. It is thus larger than that for the concrete slab. The reason is the more complex transfer of vibrational energy to the measuring points due to the inhomogeneous receiving structure.

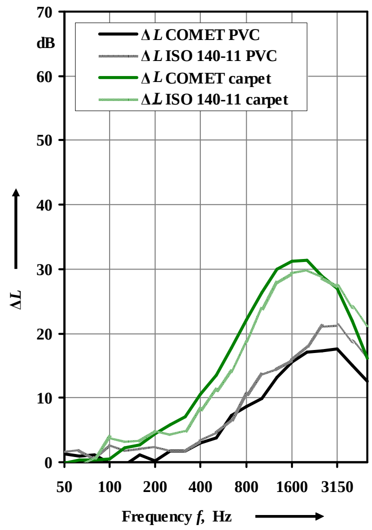

Figure 7: Impact noise reduction ΔL [dB], timber: COMET vs. ISO procedure

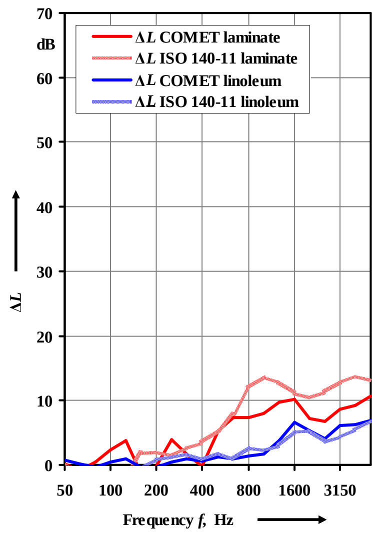

Figure 8: Impact noise reduction ΔL [dB], timber: COMET vs. ISO procedure

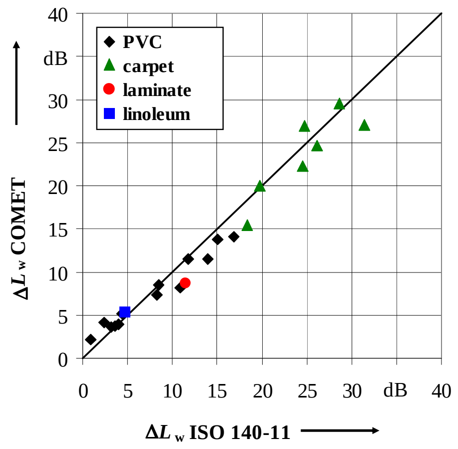

Figure 9: Deviation of ΔL_w [dB], timber: COMET vs. ISO procedure

Figure 10: Construction of COMET, concrete floor

Summary

A new compact measurement set-up was developed which can be used without adaptation and which provides good results, low effort, and easy handling and therefore fulfils the requirements. The basic idea consists in substituting the measurement of the sound pressure in 1/3 octave bands in the receiving room with the measurement of the acceleration levels in 1/3 octave bands at the bottom of a massive concrete slab or timber joist floor. The relatively low deviations between the results obtained by the COMET and ISO procedure are the results of the similarity between these two procedures. To understand the larger deviations for the timber joist floor and for the laminate, a comprehensive model of the whole measurement procedure will be developed in the future. It will particularly be investigated under what circumstances the results of the COMET - and ISO procedure are in good agreement.

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Figure 11: Construction of COMET, timber floor

References

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[4] ISO 140-8: Acoustics – Measurement of sound insulation in buildings and of building elements (Part 8: Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a heavyweight standard floor), CEN (1995)

[5] ISO 140-11: Acoustics – Measurement of sound insulation in buildings and of building elements (Part 11: Laboratory measurements of the reduction of transmitted impact sound by floor coverings on lightweight reference floors), CEN (1995)

[6] ISO 717-2: Acoustics – Rating of sound insulation in buildings and of building elements (Part 2: Impact sound insulation), CEN (2004)