Influence of Flanking Transmission on Impact Sound Insulation in Solid Multi-Dwellings

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Introduction

The transmission of impact sound takes place along the separating floor but also along the flanking building elements. The influence of flanking transmission on impact sound depends on the surface mass of the separating and the flanking elements. There is evidence that the impact sound pressure level strongly depends on flanking transmission and hence the flanking transmission has to be considered in calculation models.

Impact Sound Calculation in Standards

So far in Germany the impact sound transmission is calculated according to "Beiblatt 1" of the German standard DIN 4109 "Schallschutz im Hochbau" [1]. In this standard the impact sound transmission in solid buildings is calculated from the surface mass of the floor ($L_{n,w,eq}$) and the reduction of impact sound pressure level (ΔL) by the floor covering (floating floor). Flanking transmission is not considered separately in the calculation model. The influence of flanking transmission on impact sound is not stated explicitly in this standard.

In the future the normalized impact sound level (L_n) will be calculated according to the European standard 12354 part 2 [2]. Two calculation models for impact sound transmission in buildings are described in this part of the standard. A detailed model which calculates the impact sound pressure level frequency dependent in third octave bands and a simplified model which uses weighted values. In these calculation models flanking transmission will be considered separately.

In the detailed model input data (e.g. L_n, R, K_{ij}) has to be converted into in-situ values ($L_{n,situ}$, R_{situ} and $D_{vij,situ}$) using the structural reverberation time of the element in the laboratory $T_{s,lab}$ and the calculated structural reverberation time in the actual field situation $T_{s,situ}$. Floor coverings are included in this model using the reduction of the impact sound pressure level ΔL. Additional layers are considered by the reduction of the impact sound pressure level ΔL_d for lining on the receiving side of the separating element and the sound reduction improvement index ΔR of improvments on the flanking elements. These data for improvements have also to be converted in in-situ values. (If no in-situ values are available laboratory results can be used).

For direct transmission the normalized impact sound level pressure $L_{n,d}$ is calculated using (1)

$$L_{n,d} = L_{n,situ} - \Delta L_{situ} - \Delta L_{d,situ} \; dB \qquad (1)$$

and the normalized impact sound pressure level $L_{n,ij}$ for flanking transmission is calculated using (2)

$$L_{n,ij} = L_{n,situ} - \Delta L_{situ} + \frac{R_{i,situ} - R_{j,situ}}{2} - \overline{D_{v,ij,situ}} - \Delta R_{j,situ} - 10\lg\sqrt{\frac{S_i}{S_j}} dB \qquad (2)$$

The velocity level difference between separating and flanking element is determined by the difference between the sound reduction index of the separating and the flanking element and the direction averaged junction velocity level difference $\overline{D_{v,ij,situ}}$. The total sound transmission is calculated by adding up the normalized impact sound pressure level of the direct path and of every flanking path.

In the simplified model the flanking transmission is considered in a global way adopting a correction value K depending on the mass per unit area of the floor and the mean mass per unit area of the flanking elements. For typical German multi-dwellings (separating floors: m' = 400 kg/m² – 500 kg/m²; flanking elements: m' =100 kg/m² - 300 kg/m²) the value of K are between 1 dB, when the mean mass per unit area of the flanking walls is slightly lower than that of the separating floor, and 4 dB if the flanking elements are much lighter. Flanking elements with sound reduction improvemnts ΔR and lightweight frame construction walls are not considered in the mean mass per unit area of the flanking elements.

The values of K can be recalculated using the detailed model. Good agreement between simplified and detailed model is found, when the mass per unit area of the flanking elements does not vary too much. For equal m' of the separating and the flanking elements the portion of energy radiated by the flanking transmission is about 30 %.

Measurements

Measurements were carried out in about 45 room combinations in solid multi dwellings. The impact sound pressure level (L'_n) and the sound insulation index (R') were measured in vertical direction. The floors constructed almost of reinforced concrete (180mm - 200mm), on top a floating floor consists of about 45 mm screed on an interlayer of either mineral wool or expanded polystyrene. These are typical multi- dwellings in German building constructions.

In Figure 1 the cumulative frequency of the measured normalized impact sound pressure level $L'_{n,w}$ is shown . The legal requirements according to DIN 4109 were met in almost all measurements and the recommendations for better sound insulation according to Beiblatt 2 of DIN 4109 were met in 75 %. In five situations it was reckoned that sound bridges increase the measured sound pressure level. The wide spread of the values in Figure 1 is mainly caused by different intermediate layers between floor and screed and to a different amount of flanking transmission.

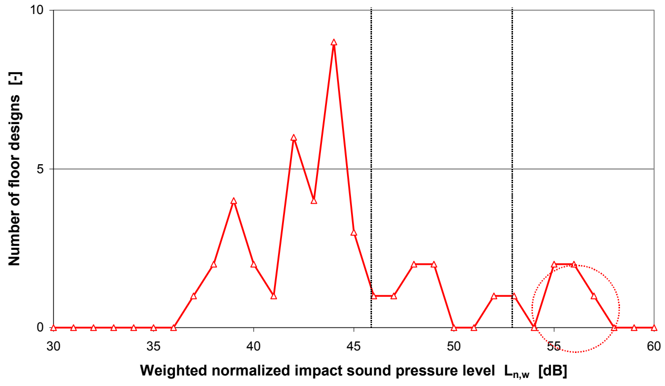

Figure 1: Occurrence of the measured normalized impact sound pressure level $L'_{n,w}$

In addition to these standard measurements the velocity levels on the separating and on the flanking elements were measured to determine the portion of the flanking transmission. This was done in in 12 room combinations. Equation (3) describes the connection between measured velocity level $L_{v,i}$ (ref 5e-8m/s) and the normalized sound pressure level $L_{n,i}$ due to the radiation of an element.

$$L_{n,i} = L_{v,i} + 6\,dB + 10\lg\sigma \quad (3)$$

Comparison of measured and predicted data

Measured impact sound pressure level and predicted one by DIN 4109 Beiblatt 1 show, that in the mean the calculated values are approximately 4 dB higher than the measured ones. The standard deviation is 4 dB.

The results of calculation according to the simplified model of EN 12354-2 are 2.5 dB higher than the measured data and using the detailed model a 3.5 dB higher calculated value occurs. The standard deviation is 2.5 dB for the simplified model and 4 dB for the detailed model.

Measurements of the velocity levels on the seperating element and flanking elements are shown in Figure 2. The measured impact normalized impact sound pressure level L'_n for direct transmission and for flanking transmission from the floor to the flanking elements is illustrated. It can be seen that the flanking walls with the smallest surface mass dominate the sound transmission.

The measurements in Figure 2 show that only 20 % of the vibrational energy is radiated by the separating floor and 80 % is radiated by the flanking elements. Furthermore the standard microphone measurement technique matches accelerometer measurements above 200 Hz. At low frequency the difference is caused by radiation efficiency which is not corrected for in equation (3). For the 12 measured room combinations the mean value of the percentage of the radiated energy by the separating floors is 30 %.

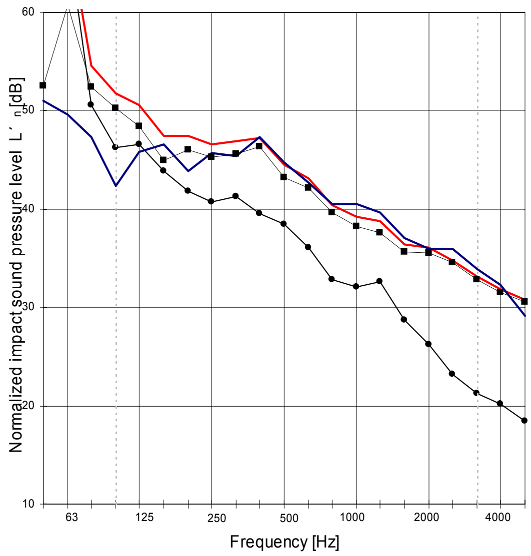

Figure 2: Normalised impact sound pressure level L'_n for direct (circles) and for flanking (squares) transmission. Measured with accelerometer (blue line) and microphone (red line)

Comparing the amount of direct and flanking transmission it is found that both the detailed and the simplified model do overestimate the direct transmission and underestimate flanking transmission.

Summary

Flanking Transmission does influence the impact sound transmission strongly. The 12 situations analysed in detail indicate that 70 % of the radiated sound power is due to flanking elements. Both, the simplified and the detailed model do overestimate the direct transmission and predict flanking transmission of about 30 %.

Although the calculation according to DIN 4109 does not include the flanking transmission explicitly, the accuracy of this calculation procedure for typical German building constructions is just slightly worse.

All calculation models do overestimate the normalized impact sound pressure level. This seems due to an underestimation of the reduction of impact sound ΔL_w by the floating floor. The accuracy of the prediction is limited by workmanship on the floating floor.

References

[1] DIN 4109 Schallschutz im Hochbau Beiblatt 1, 1989

[2] EN 12354-2 Building acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 2: Impact sound insulation between rooms, 2000