Vibration transmission indices at junctions with cavity walls

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Introduction

The sound insulation between dwellings may be improved by applying cavity walls without wall ties

However, then the sound insulation is limited by flanking transmission, in which the junction properties, characterized by the vibration transmission index K_{ij}, play an important role. K_{ij} is determined from formulas (1) and (2).

$$K_{ij} = \overline{D_{v,ij}} + 10 \frac{l_{ij}}{\sqrt{a_i \cdot a_j}} \quad \text{[dB]} \qquad (1)$$

$$a = \frac{2{,}2\pi^2 \cdot S}{c_0 \cdot T_s} \sqrt{\frac{f_{ref}}{f}} \quad \text{[m]} \qquad (2)$$

D_{vij}	= direction averaged velocity level difference between element i and j [dB]
l_{ij}	= coupling length between element and j [m]
$a, a_i\ a_j$	= loss factors of relevant elements [m]
S	= area of relevant elements [m^2]
T_s	= structural reverberation time [s]
c_0	= velocity of sound in air, 340 [m/s]
f	= band centre frequency [Hz]
f_{ref}	= reference frequency, 1000 {Hz]

The values of K_{ij} of junctions made of single homogenous building elements are rather well known. For junctions of cavity walls however, the values of K_{ij} are not known quite well, partly because of lack of data from practice. Instead of this, empirical values are used in computer models, based on EN 12354-1 [1].

Therefore, measurements have been carried out in practice, during construction, to determine the values of K_{ij} at several junctions with cavity walls made of aerated concrete.

Also experiments have been done to get an impression of the accuracy of the test method and the situation-independence of K_{ij}.

Test objects; junction types

Measurements have been done on 3 types of junctions: cavity wall-floor on 1st and 2nd floor and cavity wall-façade constructed with aerated concrete (Figure 1).

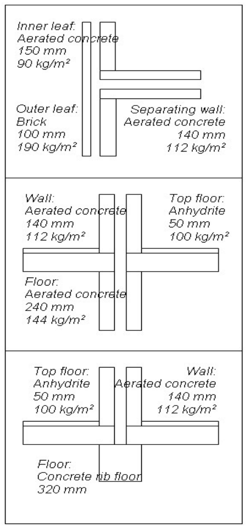

Figure 1: Junctions with cavity walls; the outer leaf has a dilatation at the cavity wall. Façade cavity, width 70 mm, filled with mineral wool; inner and outer leaf are connected by 4 wall ties per m^2.

Test method

The vibration level differences have been determined according to ISO 10848 using a battery-operated 2-channel impulse response Dirac measuring system [2]. The walls and floors were excited by means of a rubber hammer (Figure 2). Measurements have been confined to the octave bands 63-500 Hz for reasons of modal density and signal-to-noise ratio. Also the structural reverberation time was determined with this system.

Figure 3 shows the results of 6 successive measurements on the same junction, path wall-wall on the 2nd floor; the standard deviation is 1-2 dB.

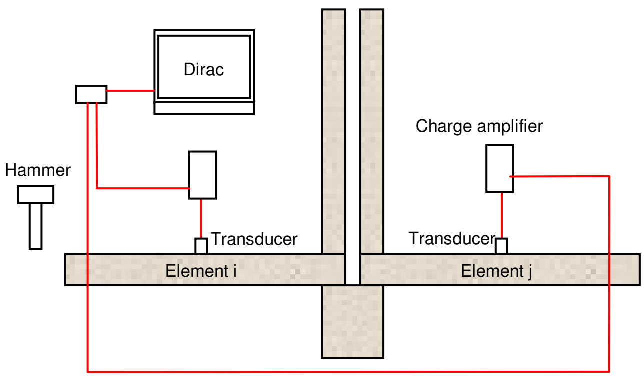

Figure 2: Measuring system

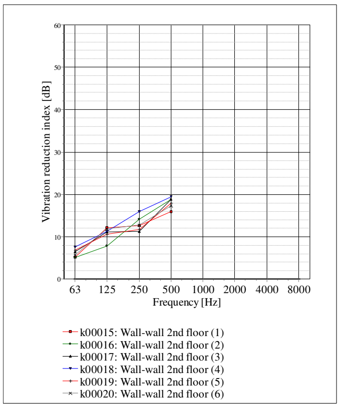

Figure 3: Results of repeatability measurements on one transmission path, wall-wall on 2nd floor.

Craftmanship; invariance of K_{ij}

To get an idea of the accuracy of constructing a junction in practice, several measurements should preferably be done on one transmission path of 1 junction in exactly the same situation, but on different locations.
On this, building site however, K_{ij} could only be determined at the junction cavity wall-floor on 2nd floor level, for the transmission path: wall-wall, on 6 locations with different coupling lengths and floor areas (Figure 4) . The results are presented in Figure 5, showing a larger variation at 63 and 125 Hz than those of Figure 3. Probably, the results are a mixture of craftsmanship and the invariance (or not) of K_{ij} in different situations.

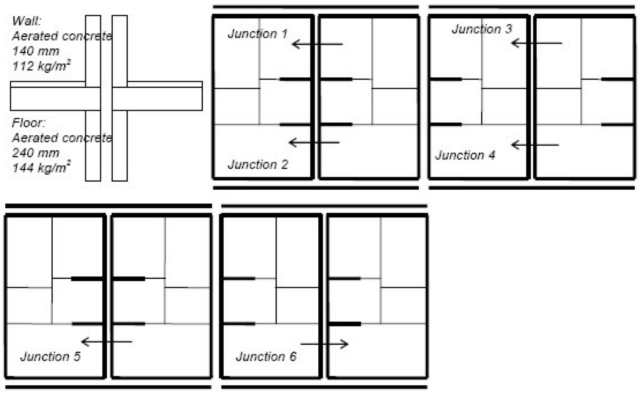

Figure 4: One transmission path on 6 different locations; thin lines are lightweight walls

Measurements vs calculations

According to the model in EN 12354-1 the vibration transmission index K_{ij} does not depend on the coupling length between 2 elements of a junction. To investigate this, measurements have been done on 3 identical junctions at 3 different locations concerning the junctions:

- floor-wall junction at 1st floor level
- floor-wall junction at 2nd floor level
- façade-wall junction at 1st floor level

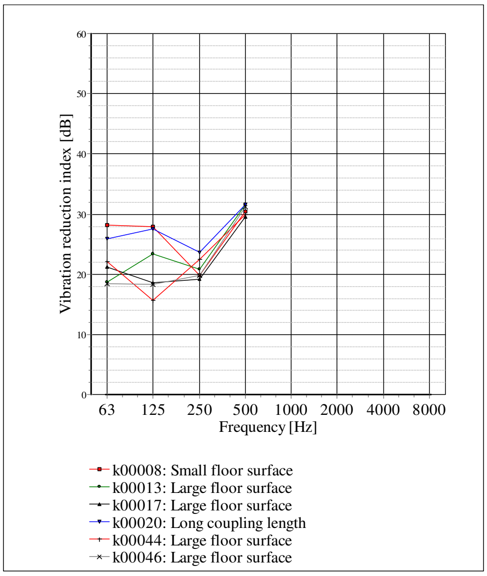

Figure 5: Vibration transmission indices of 1 path on 6 different locations, wall-wall on 2nd floor

For each junction K_{ij} has been calculated according to the model of EN 12354-1. The computerprogram BASluco determines K_{ij} along one transmission path by splitting up the path into several subpaths, determining the velocity level difference for every subpath and adding these differences like in Figure 6 [3].

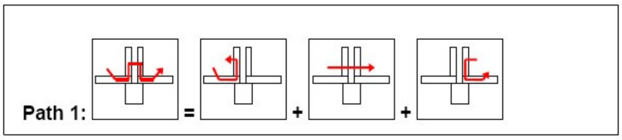

Figure 6: Example of subpaths in a transmission path.

Floor-wall junction at ground floor level

The plans and the junctions on 1st floor level are shown in Figure 7 The junctions differ in coupling length; the receiving room volumes are equal.

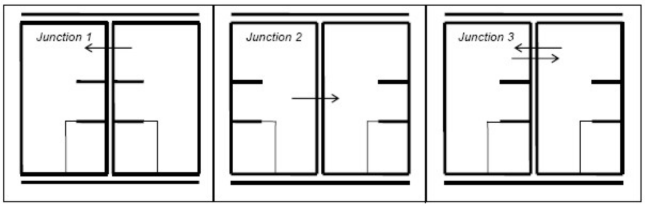

Figure 7: Plan and junctions at 1st floor level

As usual with computer programs real structures have to be simplified to fit into the program's input possibilities; this is especially the case at this junction. The real floor and its substitute are shown in Figure 8; the real junction detail and 2 possible substitutes, no cavity and a deep cavity, can be seen in Figure 9.

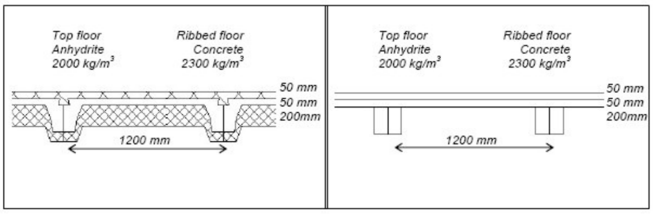

Figure 8: Floor and its substitute

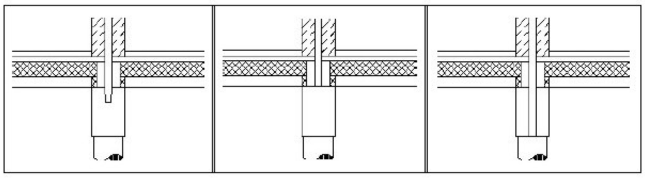

Figure 9: Junction detail and 2 substitutes

Figures 10 and 11 show the results of measurements and calculations for the path floor-floor and floor-wall respectively.

The measured values of K_{ij} are frequency-dependant and lie in between the calculation results with the 2 substitutes of the junction detail.

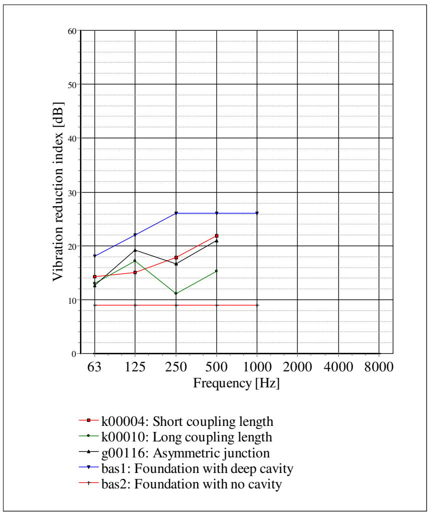

Figure 10: Vibration transmission indices of the floor-floor path on 3 different locations, 1st floor

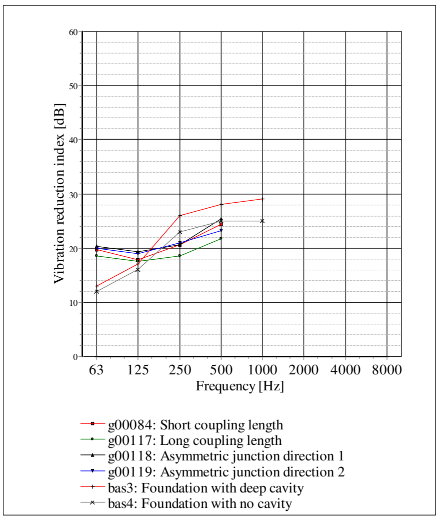

Figure 11: Vibration transmission indices of the floor-wall path on 3 different locations, 1st floor

Floor-wall junction at 2nd floor level

It concerns the junctions 1, 2 and 3 of Figure 4, characterised by a small receiving room area, a large receiving room area and a long coupling length respectively. The results of measurements and calculations of the paths floor-floor and floor-wall are shown in Figure 12 and 13 respectively.

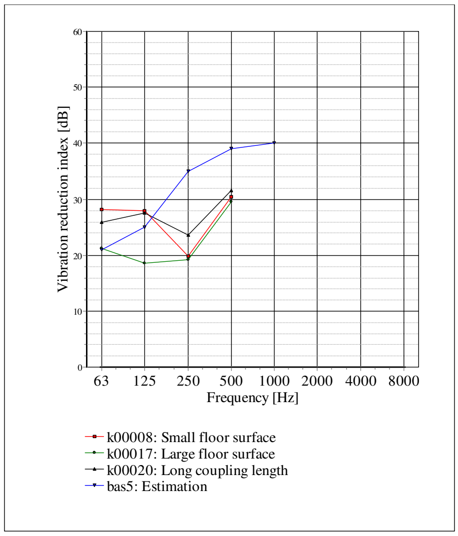

Figure 12: Vibration transmission indices of the floor-floor path on 3 different locations, 2nd floor

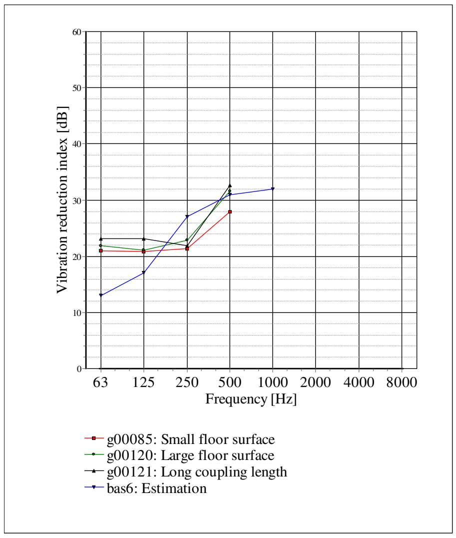

Figure 13: Vibration transmission indices of the floor-wall path on 3 different locations, 2nd floor

Facade-wall junction at 1st floor level

Measurements and calculations have been carried out on the paths facade-facade and facade-wall. During construction there was an opportunity to do measurements on the facade-facade path before the outer leaf had been erected. Calculations have been done both without a cavity in the floor-wall detail and with a deep cavity. The floor plan is shown in Figure 14, the measurement and calculation results in Figures 15 and 16.

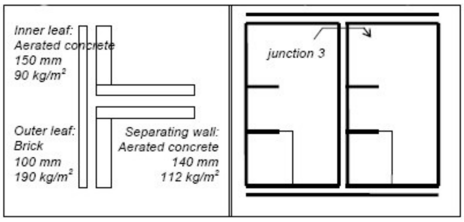

Figure 14: Façade-wall junction at 1st floor level

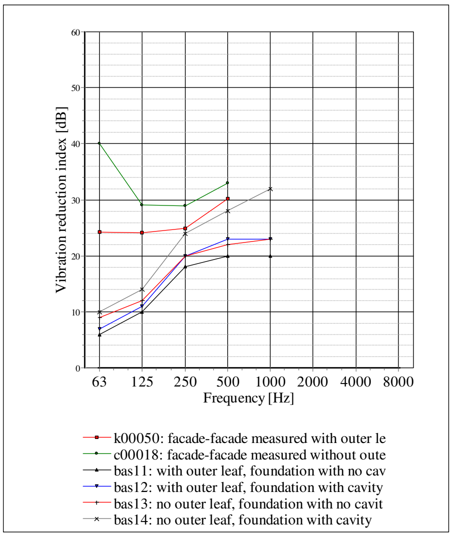

Figure 15: Vibration transmission indices of the façade-facade path, 1st floor level

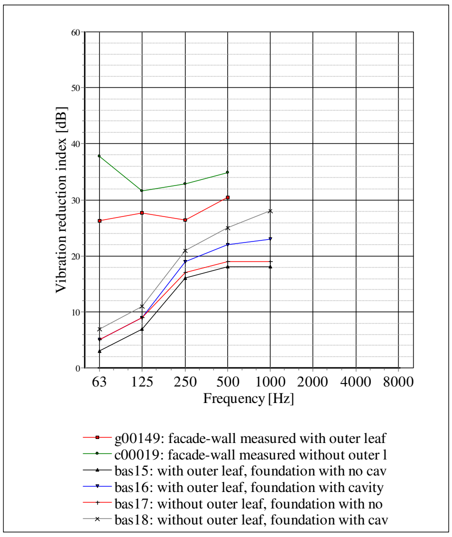

Figure 16: Vibration transmission indices of the facade-wall path, 1st floor level

Conclusions

The repeatability of the test method is reasonable for measurements in practice.

Measurement results seem to depend on craftmanship at 63 and 125 Hz, when looking at the results of repeatability measurements.

The values of K_{ij} for the path floor-floor at the 1st floor junction depend on the modeling of the cavity between the floors: no cavity or a deep cavity. Measurements lie in between the results for these 2 subsitutes. For the path floor-wall, calculations yield lower values at low frequencies and higher values at high frequencies.

For the path floor-floor at 2nd floor level, calculations yield about the same values for K_{ij} at low frequencies and higher values at high frequencies, whereas the path floor-wall shows the same tendencies as the same path on 1st floor level: lower values at low frequencies and about the same values at high frequencies.

The vibration transmission indices at he facade-wall junction at 1st floor level are underestimated by the calculations for both paths, in contradiction to results from previous research [4]. Also the frequency-dependancy is quite different. Adding the outer leaf to the inner leaf yields lower values for K_{ij}.

Looking at the calculation results, the values of K_{ij} for both paths facade-facade and facade –wall, seem to be influenced by the choice of the substitute cavity at floor level (no or deep cavity.

References

[1] EN 12354-1: Building Acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 1: Airborne sound insulations between rooms, (2000)

[2] EN ISO 10848-4: Acoustics –Laboratory measurement of the flanking transmission of airborne and impact soud between adjoining rooms – Part 4: Application to all other cases, (2005)

[3] BASluco, Stichting Bouwresearch, (2000)

[4] Scheck, J., Fischer, H., Schneider, M., : Investigation of the sound transmission through double-leaf separating walls with respect to incomplete separation, DAGA (2004)

[5] Crispin, C., Mertens, C., Blasco, M., Ingelaere, B., van Damme, M., Wuyts, D., The vibration reduction index Kij: laboratory measurements versus predictions EN-12354-1, Inter-noise 2004 Prague, 2004

[6] Gerretsen, E., Vibration reduction index K_{ij} - a new quantity for sound transmission at junctions of building elements, Inter-noise 96 Liverpool, 1996, 1475-1480

[7] Gerretsen, E., Vibration reduction index K_{ij} for junctions of building elements with cavities, Inter-noise 97 Budapest, 1997, 693-698