Contribution to final conference FP0702

WP2: Sound Performances

Low-frequency airborne and impact sound insulation

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Content of the e-Book

- Improved procedure for measuring sound insulation between rooms: *Chapter 1*

- Proposal to use sound intensity for measuring direct impact sound: *Chapter 2*

- Methods for estimating radiation efficiency of building elements and vibration level difference of junctions: *Chapter 3*

Introduction

- Sound performances are important in lightweight buildings:
  - Poor sound insulation in the low-frequency range (20-200 Hz)
  - High-demand acoustic quality is hard to achieve

- Existing measurement methods (ISO 140)
  - Poor repeatability
  - Bad reproducibility
  - Relevance to room occupants

Improved method for Sound Insulation (I)

- ISO 140:
  - Diffuse field in rooms
  - In practice; many rooms $V<25\ m^3$
    - Non-existent diffuse field at low frequencies
    - Sampling of sound pressure level in central zone

- Measurements following latter norm:
  - Less reliable
  - Less relevant to building occupants

- COST FP0702
  - Revise ISO 140 (parts 4/5/7/14); Korea 2009
  - Draft (spring 2012): ISO/DIS 16283-1

Improved method for Sound Insulation (II)

- Two proposed measurement procedures (L_p):

  1) Default method: (for all frequencies):

    - Energy-average sound pressure level:
      - fixed microphone or a manually-held microphone
      - an array of fixed microphones
      - mechanized continuously-moving microphone
      - manually-scanned microphone

    - Measurements taken in the central zone of a room at positions away from the room boundaries

Improved method for Sound Insulation (III)

- Two proposed measurement procedures:

  2) Low-frequency method:

  - 50, 63, 80 Hz one-third octave bands in the source and/or receiving room when its volume is smaller than 25 m^3
  - In addition to the “default method”
  - Additional measurements of the sound pressure level in the corners of the source and/or receiving room
    - Using either a fixed microphone or a manually-held microphone
  - Low-frequency energy-average sound pressure (combining measurements from both procedures)

$$L_{LF} = 10 \lg \left[\frac{10^{0,1 L_{Corner}} + (2 \cdot 10^{0,1 L})}{3} \right]$$

Improved method for Sound Insulation (IV)

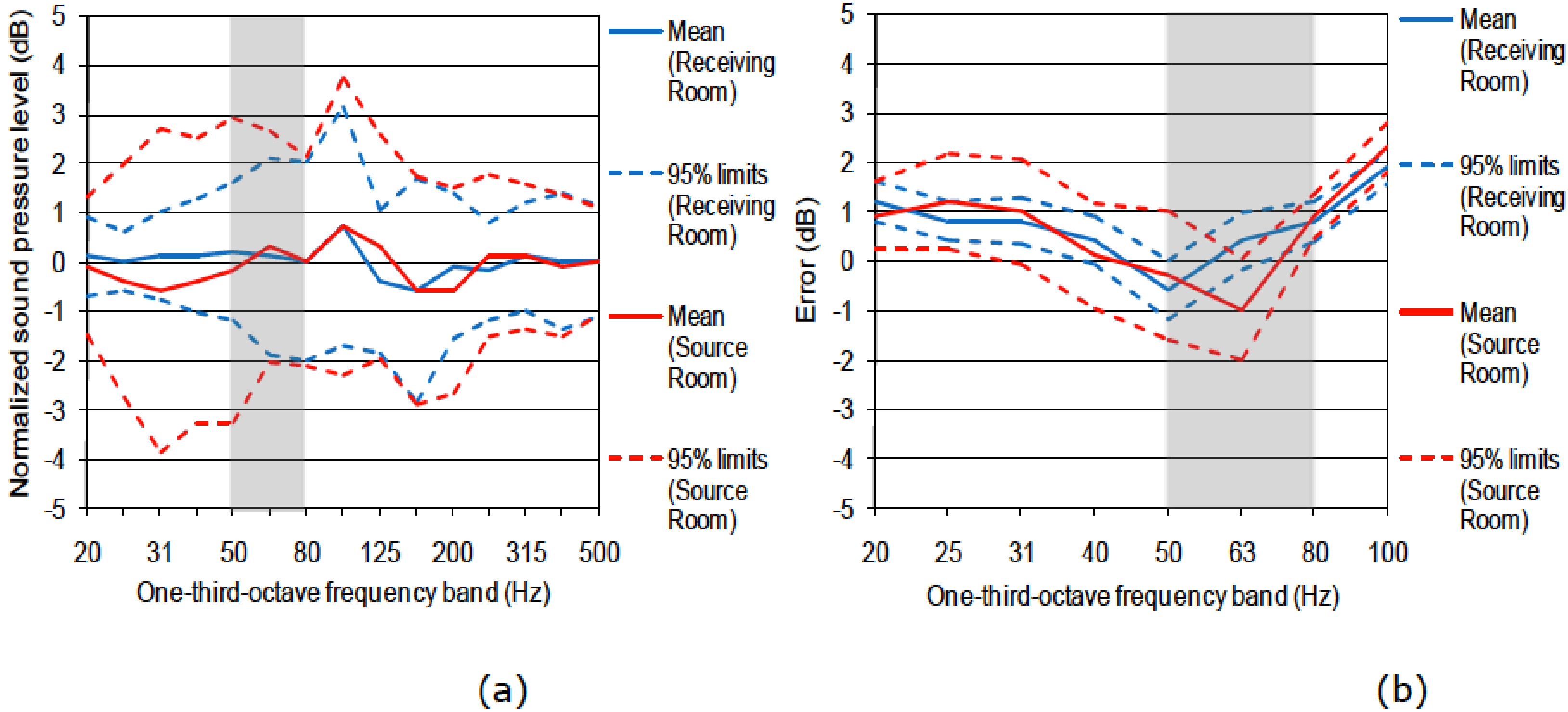


Figure 2. (a) default procedure in the central zone of a room (b) low-frequency procedure using corner measurements. NB Grey shaded areas highlight the 50, 63 and 80 Hz one-third octave bands.

Improved repeatability *[C. Hopkins and P. Turner]*

Improved method for Sound Insulation (V)

- Reverberation time:
  - The decay of the RT curve in rooms (using gypsum or timber board) can be sufficiently short that may be affected by the decay time of the one-third octave band filters in the analyser (in the 50 Hz, 63 Hz and 80 Hz bands)
  - Possible solution: use of a 63 Hz octave band filter due to its wider bandwidth which allows the measurement of shorter reverberation times

Improved method for Sound Insulation (VI)

- Reverberation time (cont):
  - Solution proposed in ISO/DIS 16283-1
    - Default procedure (receiving room for all reverberation times)
    - Low-frequency procedure ($V_{receiving}$<25m^3)
      - RT measured in the 63 Hz octave band instead of the 50/63/80 Hz one-third octave bands (single value for D_{nT} and/or R'' calculation)

One-third-octave band centre frequency (Hz)	% satisfying *BT* > 8 criterion	
	Using individual decay curves	Using ensemble average decay curves
50	37 %	33 %
63	48 %	57 %
80	87 %	86 %

Octave band centre frequency (Hz)	% satisfying *BT* > 8 criterion	
	Using individual decay curves	Using ensemble average decay curves
63	98.8 %	100 %

[C. Hopkins and P. Turner]

Table 1. Percentage of reverberation times satisfying the BT>8 criterion in timber and steel frame buildings when using one-third octave bands compared to octave bands.

L_f impact sound level using intensity (I)

- Sound level and reverberation time measurements at low frequencies are still problematic
  - Intensity method is expected to cope with these shortcomings

- Governing equations:

$$L_{n,I} = L_{In} + 10 \cdot \log\left(\frac{S}{\mathrm{m}^2}\right) - 4\ \mathrm{dB}$$

Normalized impact sound (intensity)

$$L_{n,I,\mathrm{M}} = L_{n,I} - K_C$$

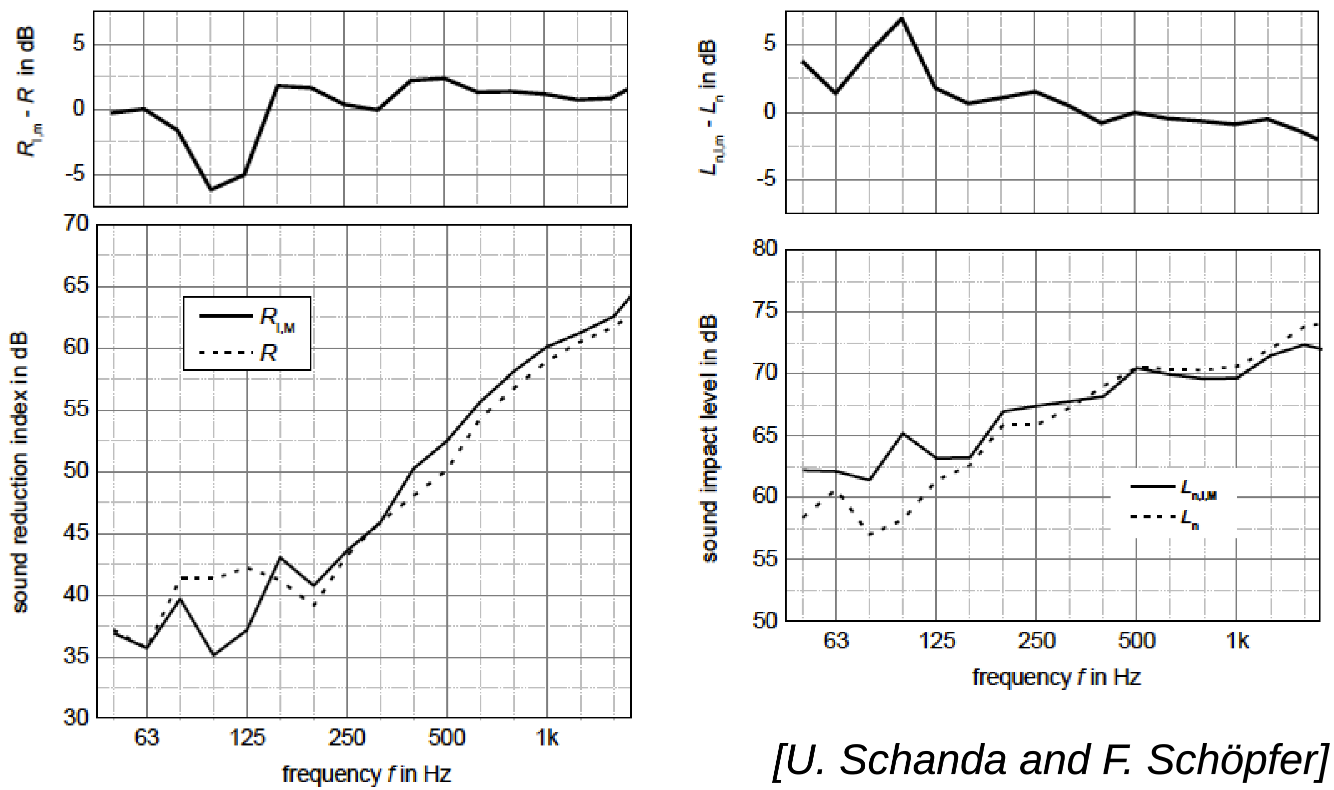
Account for sound pressure enhancement

$$K_C = 10 \cdot \log\left(1 + \frac{S_b \cdot \lambda}{8 \cdot V} + \frac{L \cdot \lambda^2}{32 \cdot \pi \cdot V}\right)$$

Waterhouse correction

L_f impact sound level using intensity (II)

- Discrepancies in the low-frequencies (lab). Further investigations



[U. Schanda and F. Schöpfer]

Figure 5: Comparison of the modified intensity impact sound level $L_{n,I,M}$ with the impact sound level L_n at the right hand side and the modified intensity sound reduction index $R_{I,M}$ according to ISO15186 with the sound reduction index R according to ISO 140 at the left hand side. At low frequencies a deviation is observable, which occured in both measurements.

L_f impact sound level using intensity (III)

- Discrepancies in the low-frequencies (in-situ)

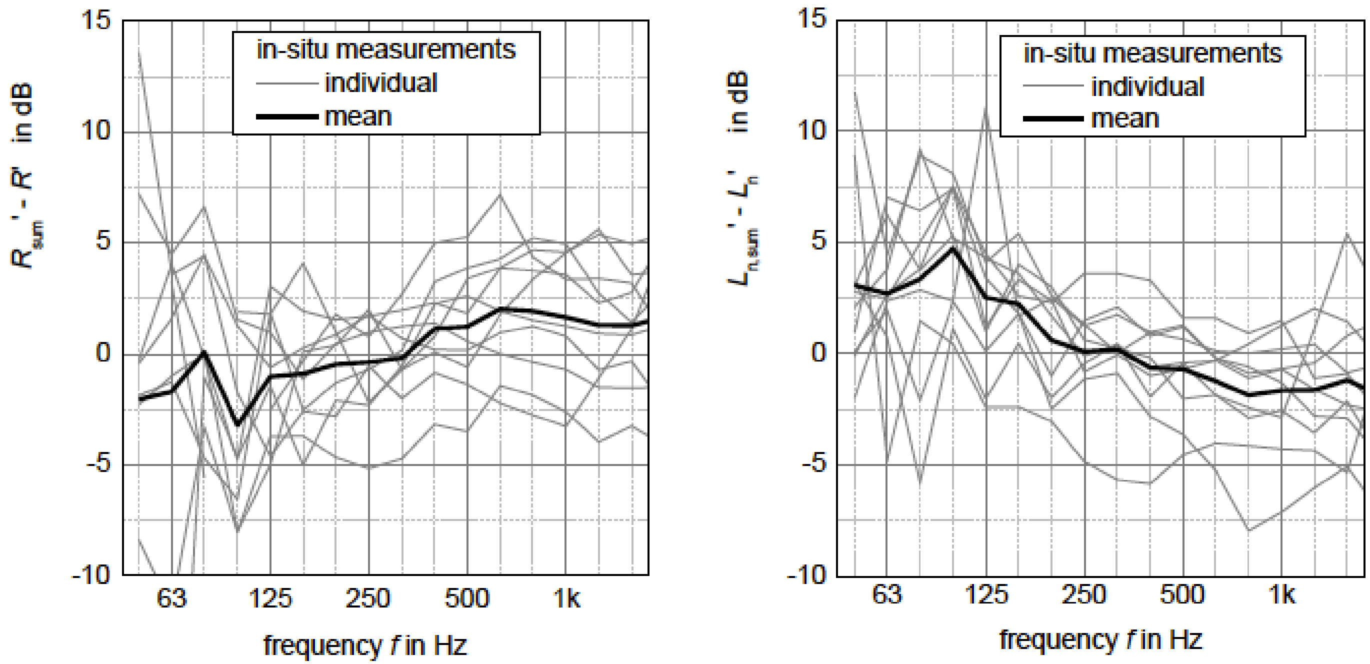


Figure 7: Comparison of in-situ measurements of airborne and impact sound insulation according to ISO 140 with results obtained by measuring the direct path of the sound transmission with intensity and the flanking paths with accelerometer and combining the contributions to a total sound reduction R'_{sum} and $L'_{n,sum}$, respectively.

[U. Schanda and F. Schöpfer]

L_f impact sound level using intensity (IV)

- The method:
  - Feasible
  - Reasonable results even in the low frequency range.
  - Advantage:
    - independency on the RT and sound level which might vary
  - Disadvantage
    - large instrumental and operating expense.

Radiation efficiency and junction vibration level difference (I)

- Governing equation (Radiation efficiency):

$$10\log(\sigma) = L_p - 6 - L_v + 10\log(A/S)$$

- Method:
  - Sound pressure measurements:
    - L_p and A: following ISO 140-3 (more methods in literature)
  - Vibrations measurements:
    - L_v measured as the junction vibration level difference method
  - Radiation efficiency
    - Highly dependent on the excitation
      - Up to 10 dB difference between mechanical and airborne excitation in *[M. Villot and C. Guigou-Carter]*

Radiation efficiency and junction vibration level difference (II)

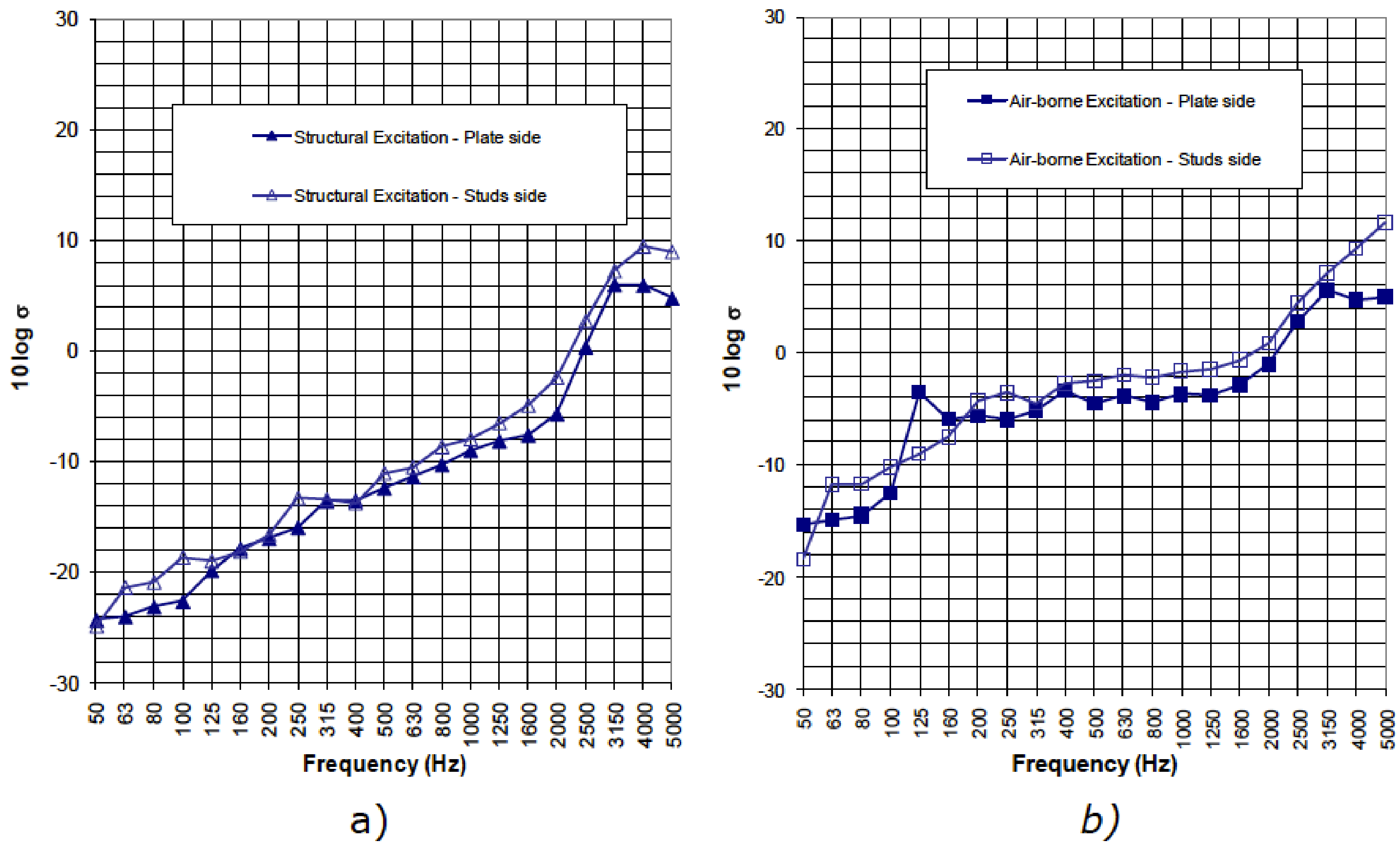


Figure 1: Measured radiation efficiency of a single leaf wall in the cases of (a) mechanical excitation and (b) airborne excitation.

[M. Villot and C. Guigou-Carter]

Radiation efficiency and junction vibration level difference (III)

- Standard EN 10848 series proposes two methods of measuring flanking transmission of airborne and impact noise between adjoining rooms
  - Shielding building elements (cumbersome)
  - Vibration level difference (diffuse excitation)

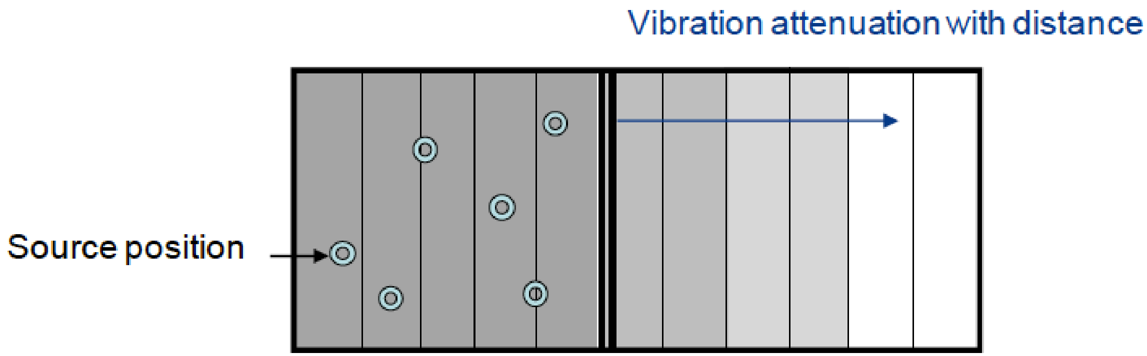
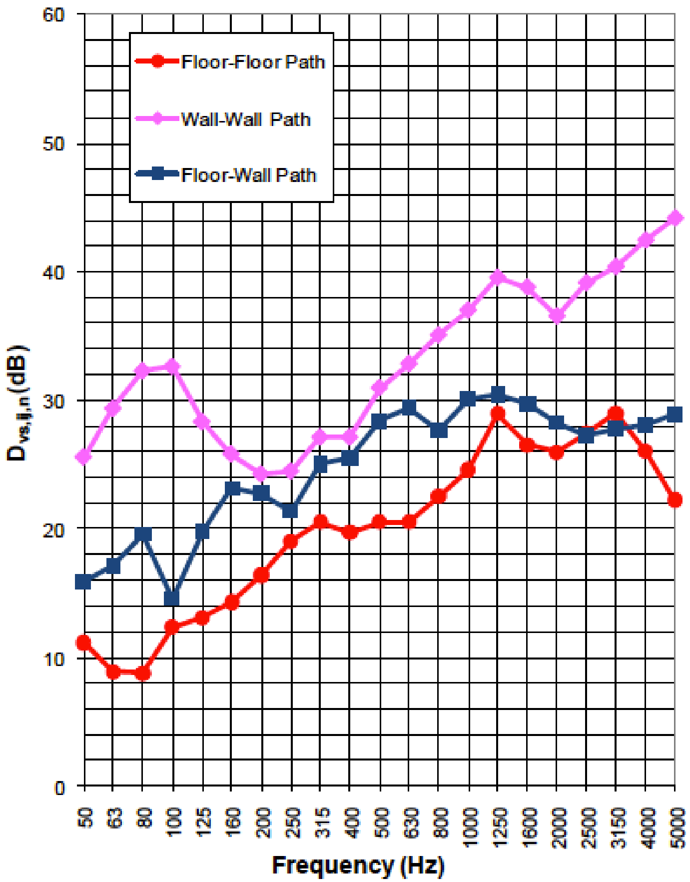


Figure 3: Top-view of a lightweight floor/wall junction with joists // junction

Radiation efficiency and junction vibration level difference (IV)

- Vibration level difference: $\overline{D_{v,ij,situ}} = \overline{D_{v,ij,n}} - 10\log(l_{ij,situ} / \sqrt{S_{situ,i}.S_{situ,j}})$



[M. Villot and C. Guigou-Carter]

Figure 4: Measured normalized velocity level differences of a lightweight floor-wall X-junction.

Thank you for your attention!

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