Modeling of Airborne Transmission in Floor System Including Flanking Transmission

Delphine Bard [1,2], Juan Negreira [1] , Marco Kuster [2]
1. Engineering Acoustics, Lund University , Lund, Sweden
2. Kuster & Partners, Lachen, Switzerland

INTRODUCTION: In the investigations presented here, a simple model is analyzed with respect to flanking sound transmission. Modifications in a reference model were performed aiming at studying the relative differences between modelled results and thus gaining knowledge about the phenomena involved. A section of a concrete building was modelled as a reference case, subsequent modifications (in terms of e.g. adding floor topping, suspended ceiling) being performed one at the time in order to see how the airborne sound insulation varied.

COMPUTATIONAL METHODS:
Both a 2D model and a 3D model were developed; the aim being that the 2D model allowed analyzing higher up in frequency. The transmission from the upper room (sending room) to the room below (receiving room) through the floor structure, underlying ceiling (when present) and surrounding walls was investigated. Acoustic-structure interaction was included, thus accounting for resonant transmission through air cavities, e.g. between the floor structure and the suspended ceiling. All materials used for the structural components are listed in Table 1 together with their properties. The plywood and the concrete were modelled as linear isotropic materials.

Air	Concrete	Plywood	Gypsum
K=141000	E=25E+9	E=12.5E+9	E=10.7E+9
ρ=1.2	ρ=2300	ρ=710	ρ=574
c=340	υ=0.2	υ=0.3	υ=0.2
	η=0.03	η=0.01	η=0.01

Table 1. Materials properties.

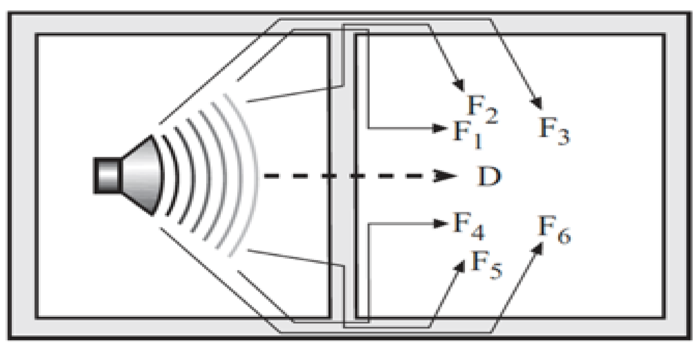


Figure 1. Airborne sound transmission. “D” denotes direct transmission whereas the “Fi” indicate the different flanking paths involved

3 monopole sources were modelled in the sending room, a frequency sweep between 20 and 3150 Hz (in the 2D case) and 1000 Hz (in the 3D case) was performed in steps of 1 Hz, the SPL[dB] being evaluated in third octave bands at a uniform grid both in the receiving (Lp,rec) and the sending (Lp,send) rooms. An energetic average of all the evaluation points in each room was performed according to $\overline{L_p}(f) = 10\log\left(\frac{1}{n}\sum_{i=1}^{n} 10^{\frac{L_{p,i}}{10}}\right)$.

The sound level difference then being extracted according to:

$$\mathrm{D}(f)[\mathrm{dB}] = \overline{L_{p,send}}(f) - \overline{L_{p,rec}}(f)$$

RESULTS: The results in terms of sound level differences for the 2D and 3D models are shown in Fig. 2 and Fig 3. In Fig. 4,5,6, the coupling of the acoustic and structural modes and their potential influence in the sound field is shown. In the case shown as a matter of example (Case 2c), one can see how the material properties can play an important role.

Name	2D/3D	Comments
REF (1a)	✓ / ✓	Bare concrete floor and discontinuous concrete walls (no flanking transmiss.)
2a	✓ / ✓	Same as the REF but considering continuous walls (i.e. flanking transmission)
2b	✓ / ✓	Same as 2a with a 0.05 thick plywood top floor (and a 3 cm gap with the walls)
2c	✓ / ✓	Same as 2b with the long walls made of plywood instead of concrete
2d	✓ / ✓	Same as 2c with a 0.1 m thick concrete-suspended-ceiling (cavity 0.05 m)
2e	✓ / ×	Same as 2d with gypsum linings on all the walls.

Table 2. All cases studied.

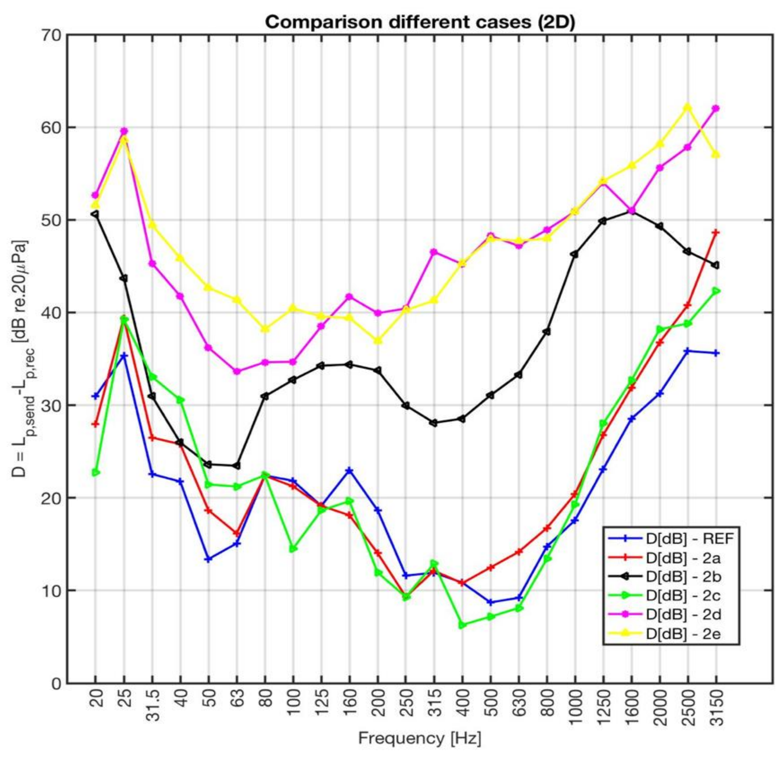


Figure 2. Level difference of 2D cases

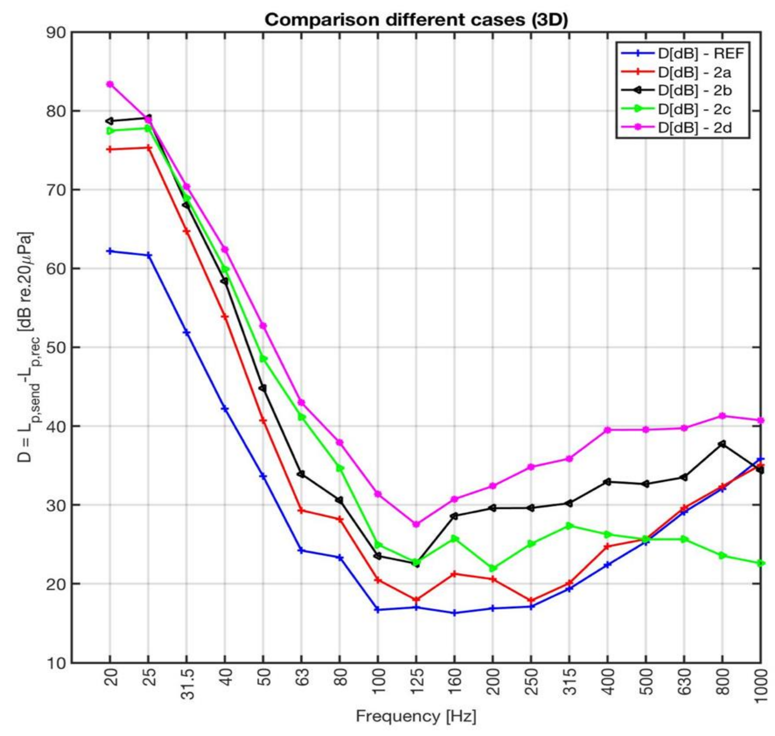
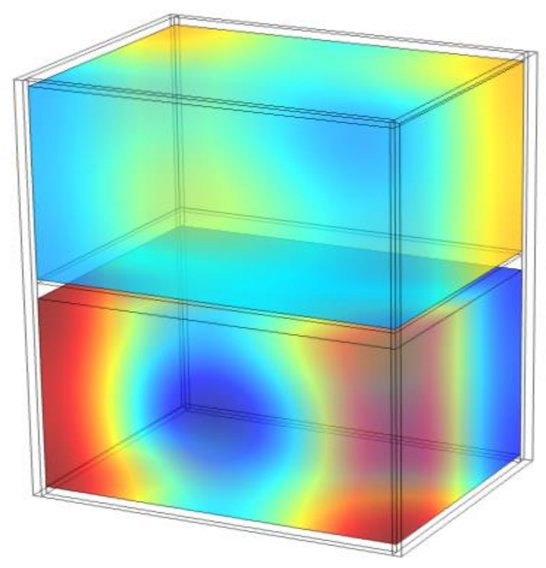
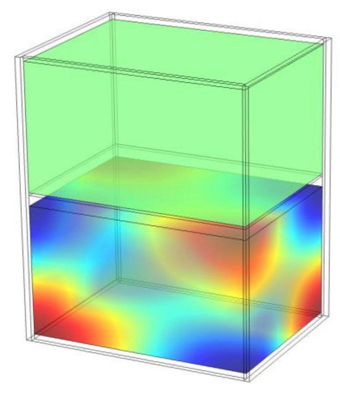


Figure 3. Level difference of 3D cases.





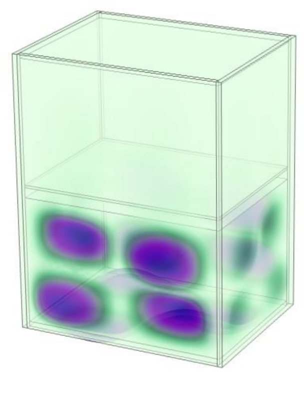


Figure 4,5,6. Acoustics modes

CONCLUSIONS: The predictions stemming from the models showed correct tendencies, however further refinements and calibrations of the model (in terms of modelling the source as well as connections) are needed in the next steps so that the absolute values can be accurately predicted.

REFERENCES:

1. CEN (2000), EN 12354-1 (ISO 15712-1:2005): Building acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 1: Airborne sound insulation between rooms, European Committee for Standardization, Brussels, Belgium.
2. ISO (2013), ISO 717-1: Acoustics – Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation, International Organization for Standardization, Geneva, Switzerland.
3. ISO (2010), ISO 10140-2: Acoustics – Laboratory measurement of sound insulation of building elements – Part 2: Measurement of airborne sound insulation, International Organization for Standardization, Geneva, Switzerland.
4. ISO (2014), ISO 16283-1: Acoustics – Field measurement of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation, International Organization for Standardization, Geneva, Switzerland.