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Comparison Between Measurement Techniques to Estimate Flanking Sound Transmission

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ABSTRACT: Flanking transmission in building structures can be estimated using the intensity technique according to the method described in the standard EN ISO 15186-2 Annex C, and using vibration velocity technique as well specified in pr EN ISO 10848-1, the reference standard for the measurement of the sound reduction index in laboratory.
This paper reports the results of the comparison between the Intensity measurement technique and the Vibration velocity based method, to estimate the flanking sound transmission for a floor – wall connection. The measurements have been performed on a laboratory with particular conditions (two suppressed junctions).

1. INTRODUCTION

In building acoustics the flanking sound transmission is a very important issue, in real situations we have sound radiating from many paths and is important to have a procedure that can be easily implemented to measure these flanking paths.
The aim of this work is to compare the results of the measurements made on a floating floor connected to a flanking wall in the same room, obtained from two different techniques Intensity measurement technique and Vibration Velocity measurements, in laboratory conditions. Through these results it is possible to calculate the contribution of each wall or flanking path and evaluate the impact sound reduction index between rooms.
The measurement with Intensity technique requires professional experience to achieve good results and it needs particular attention on the arrangement of the receiving room, putting some sound absorbing material to reduce the influence of the reverberant field, especially in buildings with high sound isolation. It is also a method that spends much time and becomes tedious when necessary measurements of all flanking surfaces. With the Vibration velocity technique the measurement procedure is faster with less cost and once implemented does not need a highly skilled experience to set instruments and perform measurements.
This work is not intended to calculate or elaborate the flanking sound reduction index, but only to compare results between measurement techniques, knowing that with them is possible evaluate the contribution of flanking paths.

2. MEASUREMENT LABORATORY

2.1 Laboratory characteristics

The measurements took place in the laboratory of building acoustics of *DIENCA* (*Dipartimento di Ingegneria Energetica, Nucleare e del Controllo Ambientale*) at the University of Bologna; the 3-D plot of the laboratory is shown in figure 1.

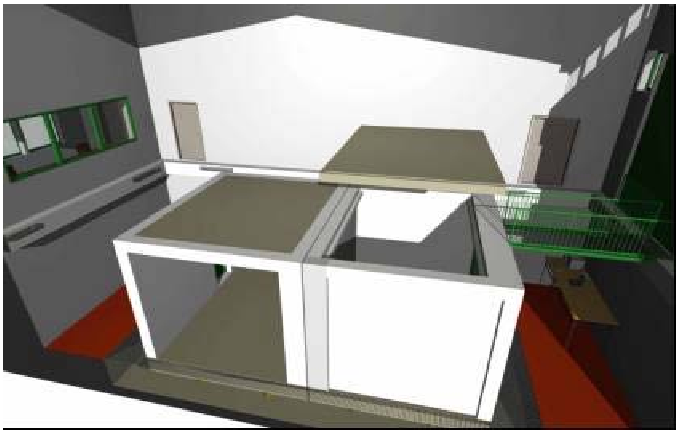

Figure 1 – 3-D view of the laboratory chambers.

The receiving room has 4,49x3,60x3,40 [m] corresponding to a volume of 55 [m^3] and is built with a concrete armed structure that is supported by a group of 4 spring-damping elements.
On the ceiling of the right compartment of figure 1 was plant the test floor of 12 [m^2]. The main layer is a 14 [cm] thick floor of armed concrete with approximately 2300 [kg/m^3] and is put down in two longitudinal beams.
The other two sides of the floor are structurally disconnected from the lateral walls and between them was placed sound absorbing material. Because the superior compartment of the laboratory is not build and to prevent airborne sound produced by the tapping machine reaches lateral walls of the receiving room, the superior part of the floor has been covered (not directly connected) by a layer of sound absorbing material with high density and the tapping machine was covered by wood box isolated with rock wool.
The reverberation time of the receiving room was measured and the values are between 1 and 2 [s] [1].

2.2 Measurement conditions

The floating floor is set on the entire surface of the concrete floor and it is composed by a 22 [mm] of expandable polystyrene EPS and is ended with a 5 [cm] concrete layer, armed with a steel frame, as can be seen in figure 2. This last layer is completely disconnected from the lateral surfaces to prevent structure borne transmissions.
The sound transmission to the lateral wall represents is this situation a first order flanking path, while the transmission to the floating floor is the main path.

The value obtained for the floating floor in terms of reduction impact sound pressure level index is $\Delta L_w = 31$ [dB] [1].

Figure 2 - Final concrete layer of the floating floor.

3. MEASUREMENTS

3.1 Intensity measurements

The equipment used for intensity measurements was composed by the sound analyzer B. & K. Type 2260 with sound p-p probe model B. & K. Type 3595 and calibrator model B. & K. Type 4297. For measurements and calibration was used a 12 [mm] spacer. It was also useful the software of B. & K. Noise Explorer™ Type 7815 and Microsoft Excel™ chart to post-process the data acquired.
The intensity measurements are performed according to the standard EN ISO 15186-2 [2] by means of scan procedure of surfaces under test, with the distinction of the mechanical excitation by using the tapping machine model B. & K. Type 3204, as an alternative the acoustical excitation by a loud speaker. For one transverse position of the tapping machine as required by the EN ISO 140-6 [6], the sound field in receiving room was generated and then the average sound Intensity level from the floor and the lateral wall of the receiving room was measured. All the measurements are made in 1/3 octave bands, between 50 and 10.000 [Hz]. Measurement conditions must be satisfactory in accordance with the requirements of the standards EN ISO 15186-2 [2] and EN ISO 9614-2 [4]: the following equation (1) is an example of one of the criteria used to comply with

$$F_{pI} < L_d = \delta_{pI_0} - 10 \quad [dB] \qquad (1)$$

where F_{pI} is the pressure-intensity indicator, L_d is the dynamic capability index and $\delta_{pI,0}$ is the residual intensity index and this last was obtained in the calibration process before starting measurement. The power level is calculated averaging between intensity scans (vertical and horizontal) and then with respect to the surface area.

Measurement scans were of 1 minute each (maximum) and the surfaces were separated in sub-areas according with the sound analyzer B. & K. 2260 software.
The floor has the dimensions of 4,49x2,66 [m] and was divided in 12 sub-areas with approximately 1,12x0,88 [m] each one and the wall of 4,49x3,39 [m] and is also divided in 12 sub-areas each one with approximately 1,12x1,13 [m].
Overall results are shown in the figure 3 for Intensity measurements of wall and floor. At low frequencies in some floor sub-areas, negative Intensity levels appear and for the flanking wall that appends more frequently at high and low frequencies, due to lower power levels, an example of one section of the Intensity measurements is shown in figure 4. These negative values (white columns of figure 4) indicate that there is sound produced by the tapping machine that is arriving to the wall by airborne transmission inside the room, instead of out coming by structure borne transmission. As a result of this, the negative values were evaluated in the Intensity charts as positive values.
This is not correct from the Intensity point of view but, our intention is to compare with the Vibration Velocity values and in fact, the wall vibrates independently from the direction of sound, so it vibrates with the structure-borne and airborne sound induced on it.
The Intensity technique has the advantage to evaluate the direction of sound propagation but to compare with Vibration technique this is not essential.

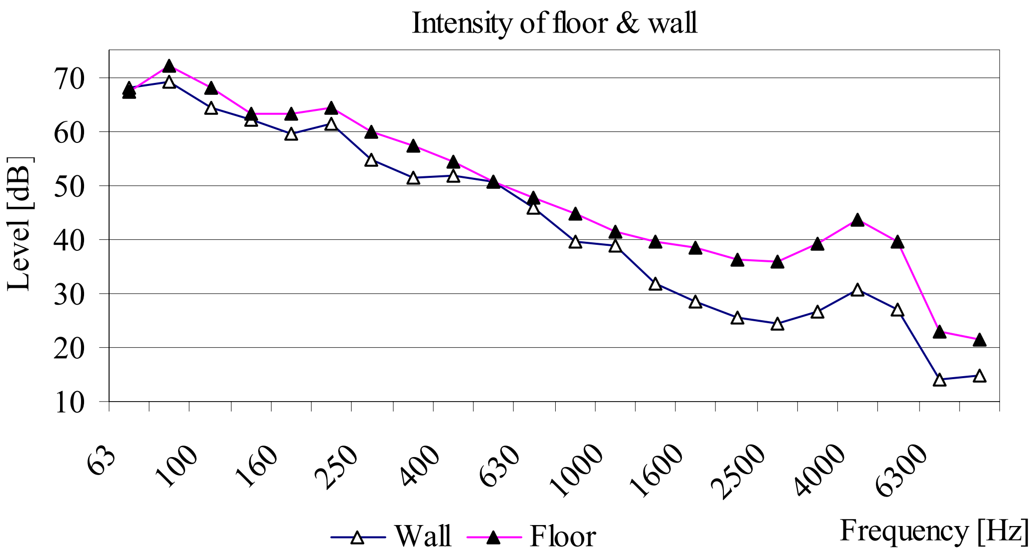

Figure 3 – Intensity measurements of floor and wall

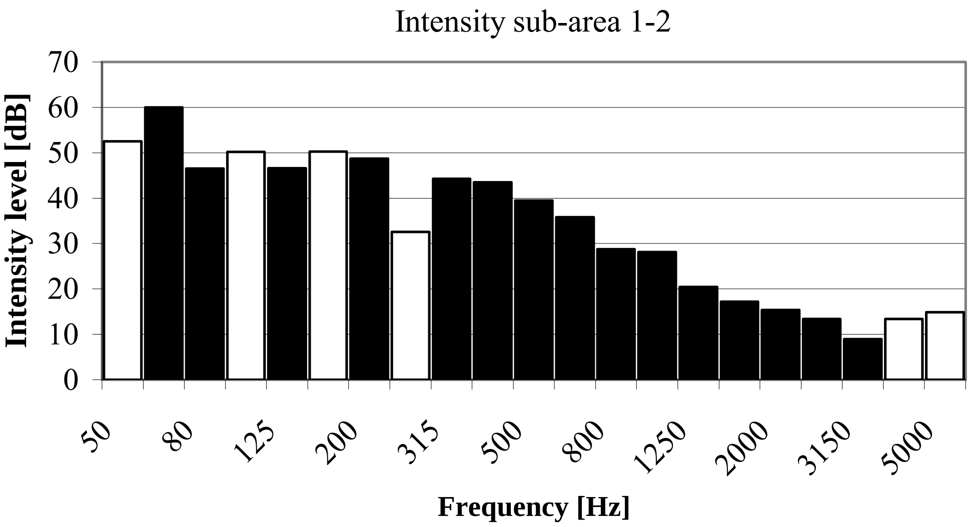

Figure 3 – Intensity level for wall sub-area 1-2

3.2 Vibration measurements

The equipment used for vibration measurements was composed by real-time analyzer model Larson Davis 2900B, a two channels conditioning amplifier of B. & K. model Nexus, where two charge accelerometers of model B. & K. type 4371V was connected. The accelerometers were screwed to the wall with a support that was fixed on the wall with glue.

There are a total of 14 measurement positions, irregularly distributed over the entire surfaces. The measurement time for each position was of 40 [s], all the measures were taken in steady-state conditions. All the data was acquired by a personal computer and post-processed with Microsoft Excel™ sheet.

To compute the power level radiated by the surface we used the equation (2) developed by [4]

$$L_{W_v} = L_V + 10\log(S) + 10\log(\sigma) \quad [dB] \qquad (2)$$

where S is the area of the surface and σ is the radiation efficiency. The radiation efficiency can be estimated for plates that are structurally excited by the equation (3) given by [5]:

$$\sigma = \frac{1}{\sqrt{1 - \frac{f_{cr}}{f}}} \qquad (3)$$

This equation was used for both surfaces. The standard EN ISO 140-6 Annex B [6] says to use the value of 1 for σ, above the critical frequency. The critical frequency was estimated using the equation (4)

$$f_{cr} = \frac{c_0^2}{2\pi}\sqrt{\frac{\rho_M h}{B}} \quad [Hz] \qquad (4)$$

where c_0, is the velocity of sound in the air is and ρ_m, is the density of the material h is the thickness and B is the bending stiffness of the floor. The critical frequency calculated for the floor is about 150 [Hz]. The bending stiffness is calculated with the following expression (5)

$$B = \frac{Eh^3}{12(1-\upsilon^2)} \qquad [N \cdot m] \qquad (5)$$

where E is the Young modulus and υ is the Poisson ratio. The vibrations measurements results are shown in the following Figure 4.

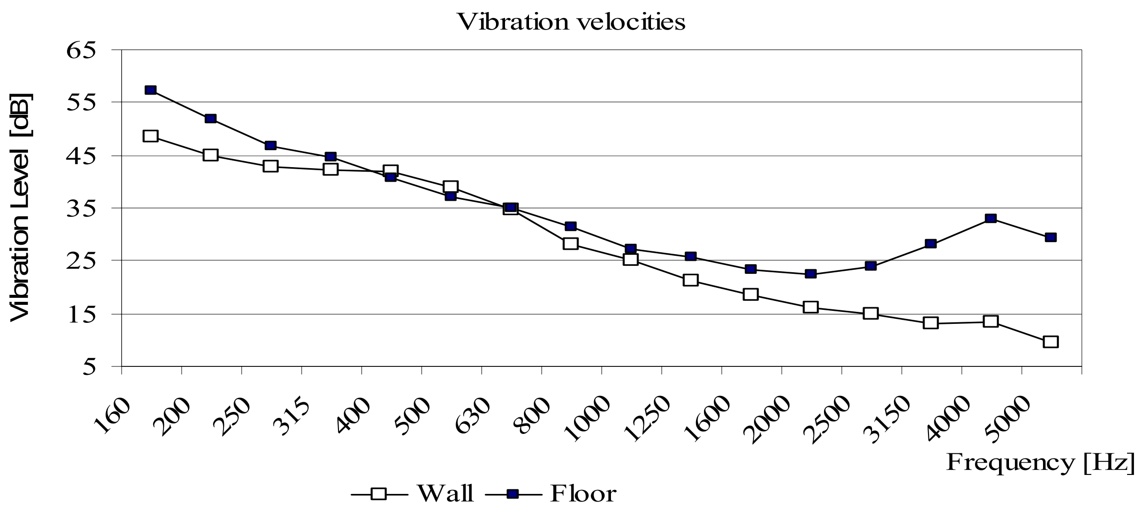

Figure 4 – Vibrations velocities for floor and wall

4. RESULTS

4.1 Floor results

The Figure 5 shows results of sound power level for the floating floor calculated with Intensity technique and Vibration Velocity technique. Both slopes have good agreement for almost frequency 1/3 octave-bands. The most visible differences are for low frequencies around the critical frequency, where Intensity technique can not give reliable values, because we have measure some negative values and for the vibrations we have the radiation efficiency that is not appropriately calculated below the critical frequency.

4.2 Wall results

The Figure 6 shows results for wall measurements in terms of power levels for Intensity and Vibration Velocity techniques. The slopes have a very good agreement for all the 1/3 octave band frequencies. Also here, can be observed at low frequencies emerging disparities between the slopes, but we think that is for the same reasons as to the floor. Here Intensity measurements obtain more negative values than for floor, for values below the 30 [dB] and for Vibration Velocity technique is detectable some mismatch in the vibration power levels slope, because the dynamic capability of the measurement chain was reached and they started measure noise. This could be avoided, increasing the amplification levels, or measuring in terms of acceleration (better dynamic capability) and then transforming the results in to velocity levels. The rising levels at 4000 [Hz] is a characteristic of the laboratory and is measured by both techniques.

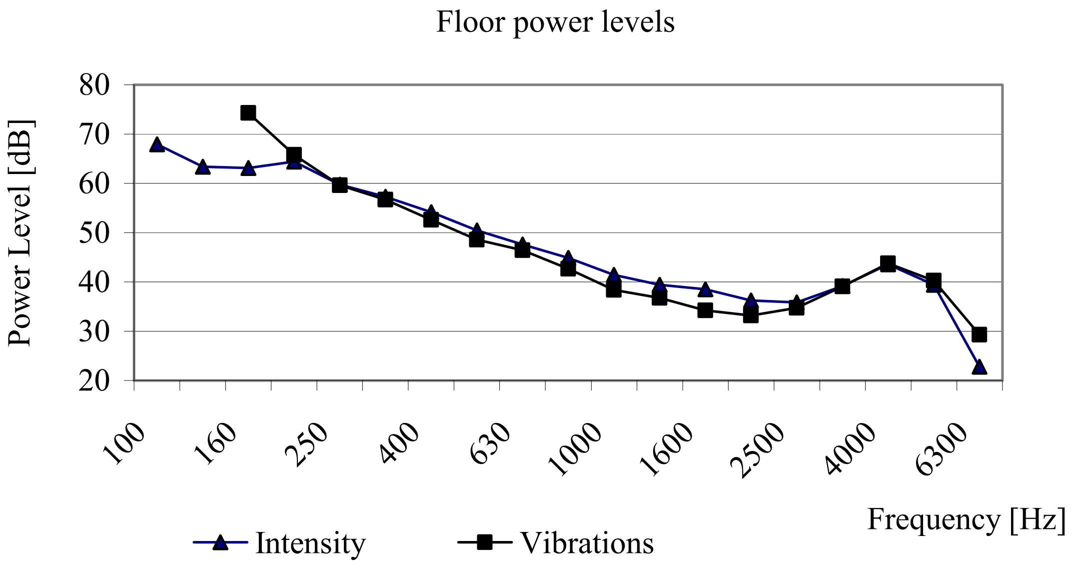

Figure 5 – Compared results for the floor

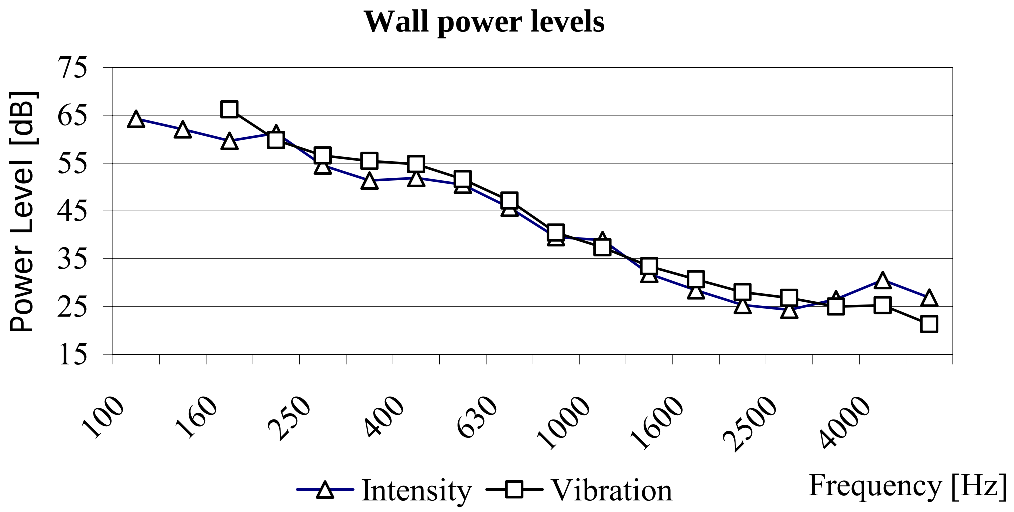

Figure 6 – Compared results for the wall

5. CONCLUSIONS

The results obtained with the vibration velocity technique are in good agreement with the Intensity technique, principally results obtained by the wall. To evaluate the contribution of the flanking paths, these results give excellent perspectives to use Vibration velocity measurement technique in replacement of Intensity measurement technique, but with Intensity we have the information about the direction of the energy flow.

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