THIS PRESENTATION IS CANCELLED (PAPER IS AVAILABLE IN THE PROCEEDINGS). Predicting and measuring the acoustic performances of lightweight based buildings

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The acoustic performances of buildings made of heavy structures and elements can be predicted from the performances of elements involved using standard series 12354.
When designing a lightweight based building, the prediction model has to be reconsidered.
This paper shows different calculations of airborne and impact sound insulation with a new proposed theoretical method. Calculations are compared to final measured results.
Other measures from Dvij are presented in order to discuss how to analyze properly a lightweight based building.

1 Introduction

In the European standard EN 12354 series, a method for predicting building acoustic performances from the performances of building elements is proposed. The method has been validated for heavy building elements but has to be reconsidered for lightweight elements.

The prediction method for lightweight constructions used in the following calculations is proposed by CSTB.

2 Prediction method

The prediction of the flanking paths is described in some public scientific papers [1]; it is briefly recalled below. Following EN 12354 prediction model [2],[3] for airborne and impact sound insulation, the flanking sound reduction index Rij and the flanking impact sound level Ln,ij from element i in the source room to element j in the receiving room can be expressed as:

$$R_{ij} = \frac{R_i^* + R_j^*}{2} + \frac{D_{vs,ij} + D_{vs,ji}}{2} + 10.\log\frac{S_s}{\sqrt{S_i S_j}} \quad (1)$$

$$L_{n,ij} = L_{n,ii} - \frac{R_j^* - R_i^*}{2} - \frac{D_{vs,ij} + D_{vs,ji}}{2} - 10.\log\sqrt{\frac{S_i}{S_j}} \quad (2)$$

Where

- R*i and R*j are the sound reduction indexes, referring to resonant transmission only, of the elements considered,
- Dvs,ij is the vibration level difference between elements i and j, when element i is mechanically excited,
- S the element surfaces (Ss for the element separating the two rooms considered),
- Ln,ii the normalized impact sound level of element i.

An expression for the correction of measured sound reduction index R values that includes both resonant and forced transmissions is based on the radiation efficiencies of the element obtained with an airborne excitation, denoted σa, and a structural excitation, denoted σs. It is given by:

$$R^* \approx R + 10.\log\frac{\sigma_a}{\sigma_s}.\frac{1-\sigma_s}{1-\sigma_a} \quad (3)$$

3 Building description

The prediction model is applied to lightweight structured row-houses. Predicted and measured airborne sound insulation values will be compared in each case study.

Airborne and impact sound insulation is evaluated in different situations with theoretical calculations and will be compared to the final measured values.

3.1 Rooms for the acoustic studies

The different rooms considered for measurements and calculations are described. The following cases were investigated in terms of acoustic performance.

Case Study 1 - Airborne insulation on ground floor in horizontal setup: the two rooms (relatively large emission room of about 25 m^3 and a relatively small reception room of about 15 m^3) are separated by a double separating wall with a concrete floor.

Case Study 2 - Impact sound insulation between two rooms in vertical setup: the two rooms (large emission and reception rooms of about 50 m^3) are separating by a lightweight wooden floor with a suspended ceiling.

Case study 3 - Airborne sound insulation between two rooms in horizontal setup on the first floor: the two rooms (relatively large emission room of about 25 m^3 and a relatively small reception room of about 15 m^3) are separated by a double separating wall with a lightweight floor.

3.2 Building Elements

Figures 5 to 7 show building construction details for the elements that compound the rooms considered for the predictions.

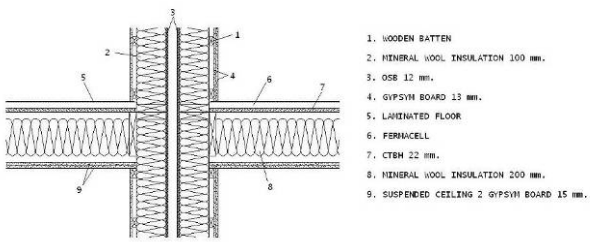

Figure 1: Elements composing the Floor and Double Separating Wall Junction

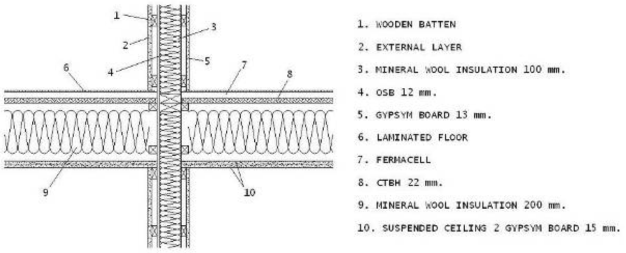

Figure 2: Elements composing the Floor and Single Wall Junction

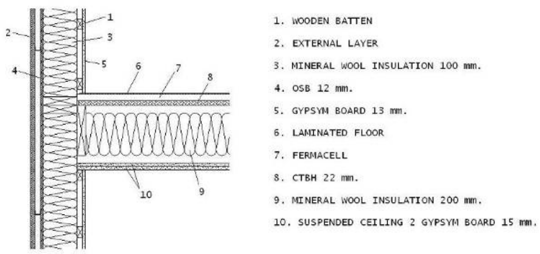

Figure 3: Elements composing the Floor and Façade Junction

4 Input data for prediction method

4.1 Elements acoustic performances

The laboratory performance of building elements (sound transmission index and impact sound level if needed) of double separating wall, internal wall, floor and recovering systems has not been tested in laboratory. A laboratory result from a similar element has been used in each case.

The only laboratory measurement results available were limited to the frequency range 100-5000 Hz; no predictions were made below 100 Hz.

4.2 Radiation efficiency

The correction factor for R* is based on element radiation efficiencies for airborne excitation and structural excitation.

$$R^* \approx R + 10.\log\frac{\sigma_a}{\sigma_s}.\frac{1-\sigma_s}{1-\sigma_a} \tag{4}$$

Correction factor is more important at frequencies much smaller than element critical frequency, i.e. in low frequency range for lightweight elements

Based on experimental results, correction factor is (roughly) simplified, as proposed in [6]:

- below element critical frequency: 10 dB
- at/above element critical frequency: 0 dB

4.3 Vibration level difference Dvij

Vibration level differences were measured in situ at some junctions. The measurement method from standard EN 10848 series is approached for the lightweight elements in situ situation [5]. The mechanical excitation is uniformly distributed over the emission plate using several tapping machine positions for floors and a "rain on the roof" hammer excitation for walls. The vibration fields were measured with 12 accelerometer position and located over the whole element in order to estimate the total energy.

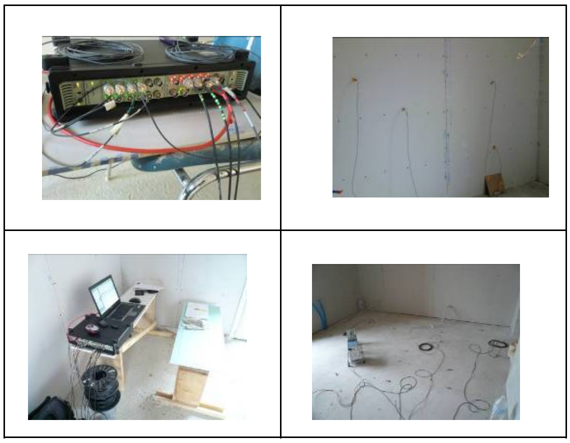

Figure 4: Vibration level difference in situ measurements

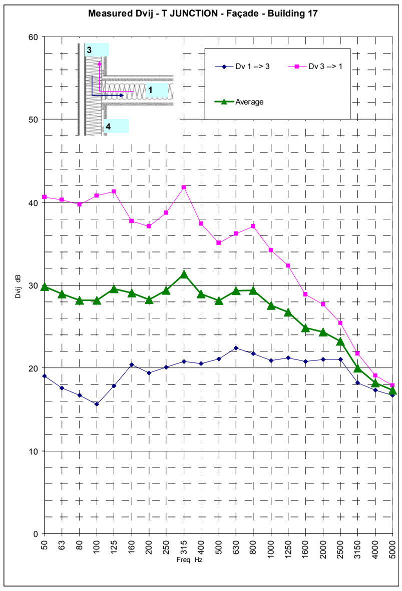

Figure 5: Measured T junction Floor-Façade. Paths 1-3.

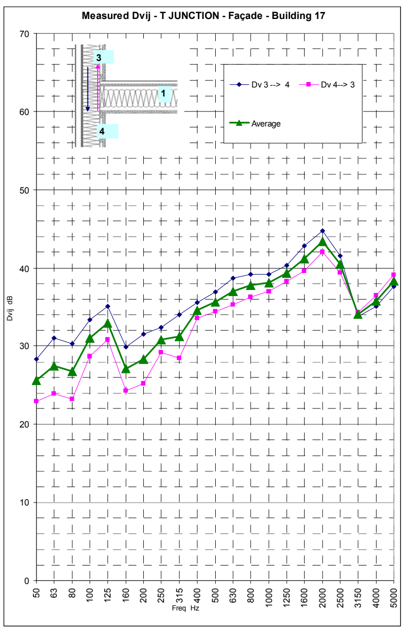

Figure 6: Measured T junction Floor-Façade. Paths 3-4

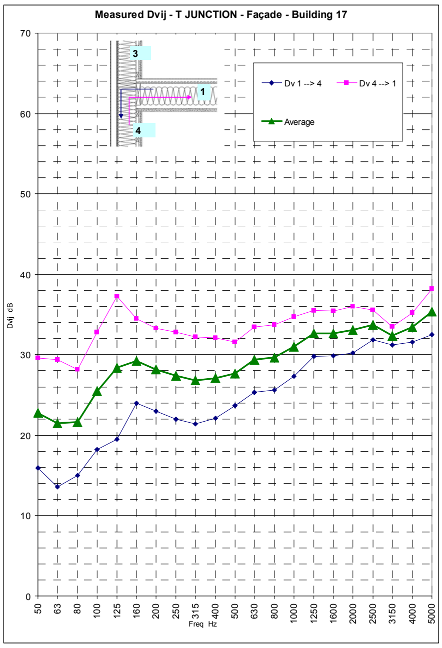

Figure 7: Measured T junction Floor-Façade. Paths 1-4.

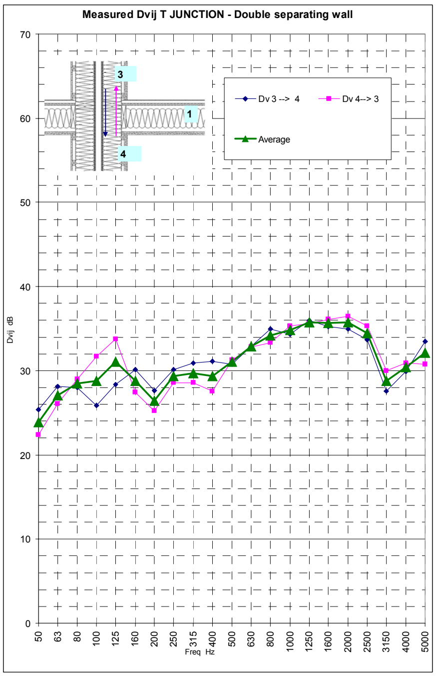

Figure 8: Measured T junction Floor-Half Double separating wall. Paths 3-4.

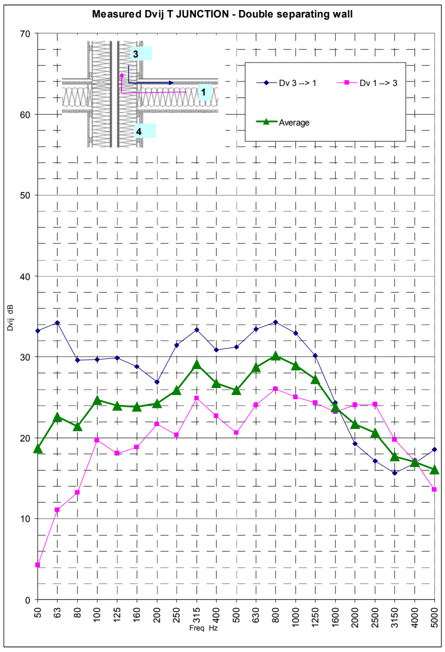

Figure 9: Measured T junction Floor-Half Double separating wall. Paths 1-3.

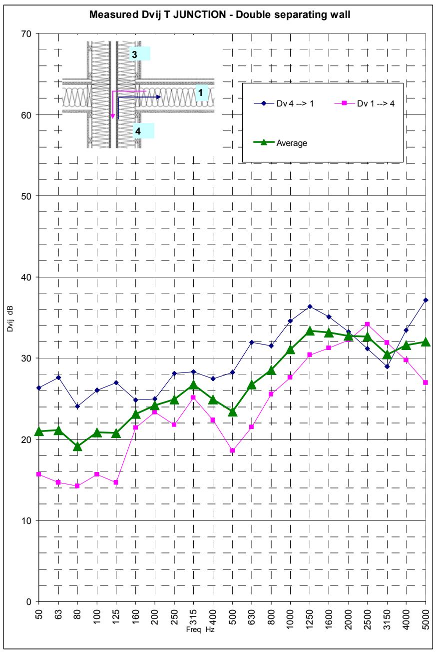

Figure 10: Measured T junction Floor-Half Double separating wall. Paths 1-4.

5 Building diagnosis

<u>CASE STUDY 1: Airborne sound Insulation in horizontal setup</u>

- Direct Path: Double separating wall (Figure 1).
- Floor path is not important because of high insulation values since the concrete is decoupled with an expansion joint.

- Ceiling path is not important because of high insulation values since the lightweight floors mounted with a suspended ceiling are independent.

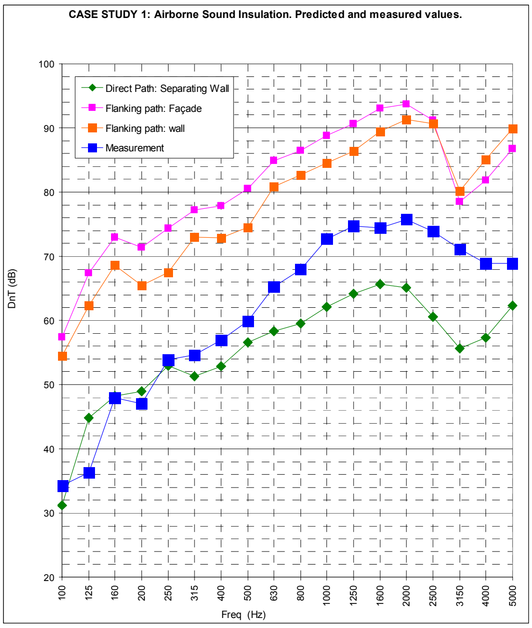

Figure 11: Case Study 1. Airborne sound insulation Comparison of predicted and measured values

The results from predicted insulation results using Dvij from measurements are compared to measurement values.

Table 1: Global indexes for horizontal airborne sound insulation

	DnT,w+C in dB
Direct path: Separating Wall	56
Flanking Path: Façade	81
Flanking Path: Wall	77
Estimated with Dvij Measured values	**56**
Measurement	**58**

→ The direct path is dominant over the flanking paths.

→ The Laboratory performance RA of the double separating wall has not been tested in laboratory. A laboratory result from a similar wall has been used. Differences at mid-high frequencies may be due to this approximation.

→ The precision of the theoretical method is 2 dB on the safe side compared to the measurement.

CASE STUDY 2: Impact sound Insulation in vertical setup.

- Direct Path: Lightweight wooden floor mounted with a suspended ceiling (Figure 2).

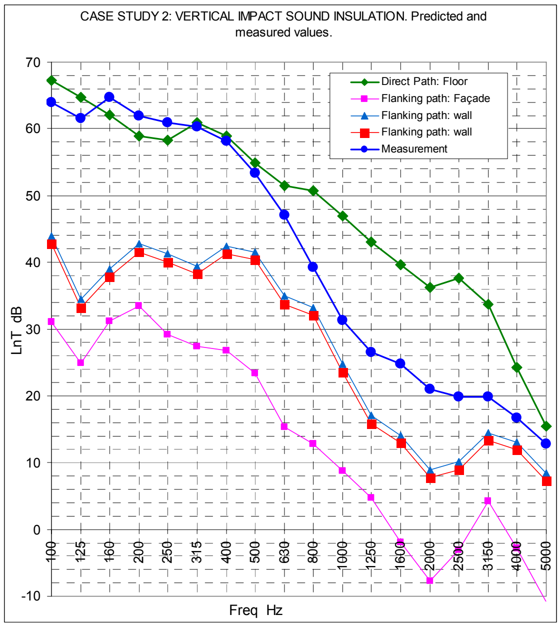

Figure 12: Case Study 2. Impact sound insulation Comparison of predicted and measured values

Table 2: Global indexes for vertical impact sound insulation

	L'nT,w in dB
Direct Path: Floor-Floor	56
Flanking Path: Floor-Façade	23
Flanking Path: Floor-Wall	37
Predicted result	**56**
Measurement	**56**

→ The direct path is dominant over the flanking paths.

→ Compared to the measured results, the L'nT predicted index is a good approach.

→ The laboratory performance Ln of the floor wall has not been tested in laboratory. A laboratory result from a similar floor has been used. Differences at mid-high frequencies may be due to that approximation.

→ The result of the theoretical method is close to the measurement value.

CASE STUDY 3: Airborne sound Insulation in horizontal setup.

- Direct Path: Double separating wall.

- Ceiling and floor paths are not important because of high insulation values since the lightweight floors mounted with a suspended ceiling are independent.

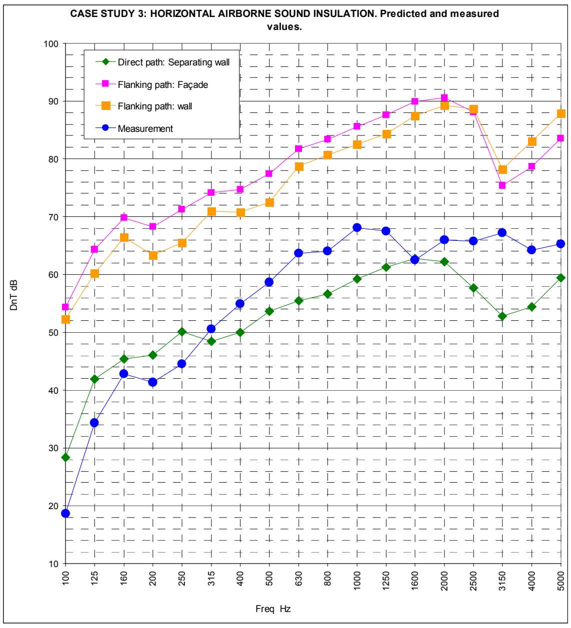

Figure 13: Case Study 3. Airborne sound insulation Comparison of predicted and measured values

Table 3: Global indexes for horizontal airborne sound insulation

	DnT,w	**C dB**
Direct path: Separating Wall	55	-2
Flanking Path: Façade	80	-2
Flanking Path: Wall	77	-2
Estimated with Dvij Measured values	**55**	**-2**
Measurement	**55**	**-8**

→ The direct path is dominant over the flanking paths.

→ The laboratory performance RA of the double separating wall has not been tested in laboratory. A laboratory result from a similar wall has been used. Differences at mid-high frequencies may be due to this approximation.

→ Compared to the measured results, the DnTA predicted index is not a good approach since the C factor applied in the measurement is very far from the C factor used in the prediction. This difference can be due to the reception room which is a bathroom.

→ Differences at low frequencies may be due to the volume of the reception room which is lower than 25m^3.

6 Conclusion

When predicting airborne and impact sound insulation with the performances of the building elements for different case studies, the direct path is dominant over the flanking paths.

The laboratory performance RA of double separating wall and Ln from the floor has not been tested in laboratory. Laboratory results from similar systems have been used; but they are limited to the frequency range 100-5000 Hz. The differences observed at mid-high frequencies may be due to this approximation.

Acknowledgments

The author wants gratefully acknowledge Catherine Guigou-Carter, Michel Villot and COST FP0702 group members for giving the possibility to achieve this work.

References

[1] M. Villot, C. Guigou Carter, "Predicting sound insulation in wood frame buildings", *Proceedings of Internoise 2009,* Otawa 2009.

[2] CEN, European Standard EN 12354-1: *Building acoustics, Estimation of acoustic performance of buildings from the performance of elements. Part 1: Airborne sound insulation between rooms*, Belgium, 2000.

[3] CEN, European Standard EN 12354-2: *Building acoustics, Estimation of acoustic performance of buildings from the performance of elements. Part 2: Impact sound insulation between rooms*, Belgium, 2000.

[4] M. Villot, C. Guigou Carter, "*Measurement methods adapted to wood frame lightweight constructions*", Journal of Building Acoustics, Vol. 13, 2006, pp189-198.

[5] C. Guigou Carter, M. Villot, "*Prediction method adapted to wood frame lightweight constructions*", Journal of Building Acoustics, Vol. 13, pp173-188.