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Effect of the estimation of the wall/floor junction type on the acoustic isolation

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Deviations between the laboratory measurement and the final in situ measurement, are common in the acoustic isolation. A fundamental difference between both cases is the effect of the lateral flanks. This effect produce that the global acoustic insulation changes substantially. With the standard UNE-EN- 12354-1, it can be estimated the effect of the flank, obtaining the vibration reduction indexes and evaluating the insulation of every way. It is also possible to carried out a measurement procedure with the Standard ISO 10848, in it the index is measured and then the index is calculated. This paper shows the differences of results of airborne sound insulation and impact insulation with in situ measurements of the vibration reduction index and the different estimations that the Standard allow . Different unions are studied, and the influence of these in the global result of the insulation is evaluated.

1 Introduction

The Basic Document Protection Against Noise (DB-HR) Technical Building Code (CTE) [1] was published in Spain in October 2007. This document is derived from Law 38/1999 of November 5, the building management (LOE) [2]. This law evolved from Directive 89/106/CEE on construction products [3]. The purpose of the harmonised technical specification for a product is to cover all the performance characteristics required by Regulations in any Member State. Although the values by regulators may be different from one member State to another.

This section of protection against noise DB-HR has just been published. To achieve this there are two possibilities. Firstly the use of simplified solutions (with typologies elements separators, thin walls, wrought iron etc.) Secondly, carry out a detailed study as indicated in the UNE 12354-6 [4,5,6]

2 DB-HR

This section carries out a review of the methods recognized in DB-HR CTE (Spain). This is intended to validate a constructive solution in terms of noise.

2.1 Simplified Method

The simplified method uses a series of one type of solutions. Some examples are shown in Figure 1.

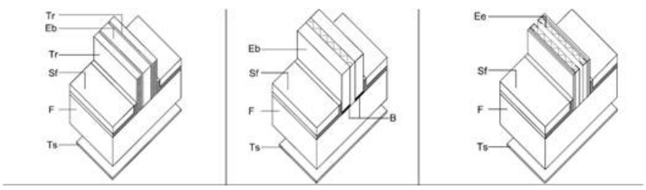

Fig.1 Simplified Solutions

To meet the requirements of DB-HR airborne sound insulation one of the solutions shown in Figure 1 may be chosen. Each material comprising part of the solutions must have a minimum value of mass per unit area and Sound Reduction Index (measured in transmission chamber). These are obtained through tables. It is assumed that with these simple solutions their individual designs are adequate and it is not considered necessary to cross boundaries.

2.2 Detailed Method

The second option is the use of the detailed method. In this case predictive methods are used. The DB-HR recognizes the valid methods that are developed in the Norm UNE-EN 12354 [4,5,6].

In this method the solution analyzed takes into account all the possible lateral transfers from transmitter enclosure to receptor enclosure (Figure 2).

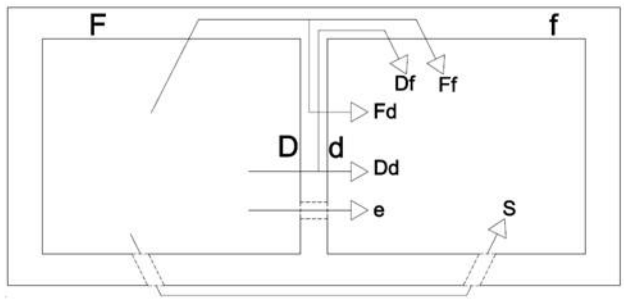

Fig 2. Ways of acoustic transmission between two enclosures

In general, for calculating the airborne noise insulation the following expression should be used:

$$R'_A = -10 \cdot \lg \left(\begin{array}{l} 10^{-0,1 R_{Dd,A}} + \sum_{F=f=1}^{n} 10^{-0,1 R_{Ff,A}} + \sum_{f=1}^{n} 10^{-0,1 R_{Df,A}} \\ + \sum_{F=1}^{n} 10^{-0,1 R_{Fd,A}} + \frac{A_0}{S_s} \sum_{ai=ei,si} 10^{-0,1 D_{n,ai,A}} \end{array} \right) \quad (1)$$

Rij,A is the Global Sound Reduction Index, for different transmission, in dB (dB(A) for pink noise)

Dn,ij,A is the difference in normal levels for the air noise transmission by different routes of transmission

The various modes of transmission, or different paths, which are described by the coefficients i, j, may be direct (Dd) or indirect (other combinations).

N is the number of flanks of the enclosure, which is normally 4 but can be varied depending on the design of the enclosure.

Ss is the shared area of element of separation (m^2)

A_0 is the absorption area equivalent reference $(10m^2)$

The values of flanks are obtained through the following expressions:

$$R_{ij,A} = \frac{R_{i,A} + R_{j,A}}{2} + \Delta R_{ij,A} + K_{ij} + 10 \cdot \lg \frac{S_s}{l_0 l_j} \quad (2)$$

Ri,A is the Global Sound Reduction Index for the i flank (dB(A) for pink noise)

RjA is the Global Sound Reduction Index for the j flank (dB(A) for pink noise)

ΔRij,A is the improvement of the Sound Reduction Index, because of the lining of the flank(dB(A) for pink noise)

These values can be obtained, directly from laboratory tests from the chosen configuration, or can be deducted for each layer involved regardless (ij= Ff; Fd o Df):Kij is the Vibration Reduction Index for the way the flanks ij(ij=Ff; Fd or Df),(dB).

This argument deserves separate consideration since it includes the effect of the union between the core and any other consideration.

Ss is the shared area of element of separation（m^2）.
Lj is the common length of the edge of union between the element of separation and elements of i and j flanks, (m).

Therefore, we can obtain the difference in standardized levels in dB(A) with the expression:

$$D_{nT,A} = R'_A + 10 \cdot \lg \left(\frac{0{,}32 \cdot V}{S_s} \right) \quad (3)$$

V is the volume of the compound receiver (m^3).

Ss is the shared area of element of separation（m^2）.

R’A is the Global Apparent Acoustic Reduction Index, (dB(A)) .

Regarding the calculation of the impact Noise insulation, figure 3 shows one example of cases that can be considered.

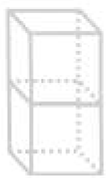

Fig. 3

In this case you have obtained the Global level pressure noise of standard impact:

$$L'_{n,w} = 10 \cdot \lg \left(10^{0{,}1 L_{n,w,d}} + \sum_{j=1}^{n} 10^{0{,}1 L_{n,w,ij}} \right) \quad (4)$$

Ln,w,d is the global level pressure noise of normalized impact , because of direct transmission, (dB)

Ln,w,ij is the global level pressure noise of normalized impact , because of indirect transmission or flanks (dB)

N is the number of flanks or element flanks, usually 4.

Although the procedure is described in the Norm, the importance of obtaining transmission indirectly to the relation should be emphasized:

$$L_{n,w,ij} = L_{n,w,situ} - \Delta L_{w,situ} + \frac{R_{A,i,situ} - R_{A,j,situ}}{2} - \Delta R_{A,j,situ} - K_{ij} - 10 \cdot \lg \frac{S_i}{l_{ij} l_0} \quad (5)$$

Ln,w,situ is the global level impact noise measured in situ (dB)

ΔLw,situ is the improvement in impact noise , because of the lining of the flank(dB(A) for pink noise)

RA,situ is the Global Sound Reduction Index , measured in situ, (dB(A))

ΔRA,j, is the improvement of the Global Sound Reduction Index, because of the lining of the element j measured in situ (dB)

Kij is the Vibration Reduction Index (dB)

Si is the area excite element (m^2)

Lij is the common length of the union between the edge of the element i and j, (m)

This gives the overall standardized level of noise pressure impact with the following expression:

$$L'_{nT,w} = L'_{n,w} - 10 \cdot \lg (0{,}032 \cdot V) \quad (6)$$

Where

V is the volume of the compound receiver, (m^3)

L’n,w is the Global pressure level in noise impact, (dB)

Therefore, if the detailed method is opted for it should reflect the effects of the flanks. In all cases the Vibration Reduction Index, Kij, is considered as a key component to calculate the effect of the union.

3 Kij Calculation

This section is a reflection on obtaining the value Kij, by different methods.

3.1 Equations recognized in Norms

In the annexes to the Norm 12354 [4,5,6] there are different equations for predicting Kij. According to the Norm these equaitions can be used under certain limitations. Figure 4 shows an example a cross-union. Figureb5 shows a union in T. Other equations can be obtained from [7] or [8,9].

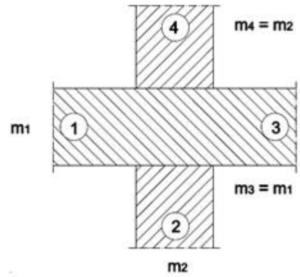

Fig 4. Rigid union in + of homogeneous elements

$$K_{13} = 8{,}7 + 17{,}1M + 5{,}7 \cdot M^2 \quad dB; \qquad 0\ dB/octava \tag{7}$$

$$K_{12} = 8{,}7 + 5{,}7 \cdot M^2 \ (= K_{23}) \quad dB; \qquad 0\ dB/octava$$

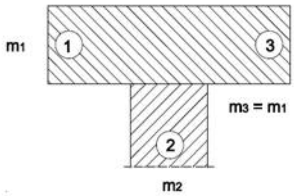

Fig 5. Rigid union in T of homogeneous elements

$$K_{13} = 5{,}7 + 14{,}1M + 5{,}7 \cdot M^2 \quad dB; \qquad 0\ dB/octava \tag{8}$$

$$K_{12} = 5{,}7 + 5{,}7 \cdot M^2 \ (= K_{23}) \quad dB; \qquad 0\ dB/octava$$

Where these expressions are, the given functions of magnitud M (and other parameters, using Kij) is defined as:

$$M = \lg \frac{m'_{\perp i}}{m'_i} \tag{9}$$

Where

m'i is the mass per unit area of the i element in the transmission path ij (kg/m^2)

m'⊥i is the mass per unit area of another element, perpendicular to i, which forms the union (kg/m^2)

3.2 Experimental method

From the point of the Kij experiment the following equation is determinated:

$$K_{ij} = \overline{D_v} + 10 \log \frac{l_{ij}}{\sqrt{a_i \cdot a_j}} dB \tag{10}$$

Where:

$\overline{D_v}$ is the velocity average in the union i-j.

l_{ij} is the length of coupling between i and j (m)

a_i and a_j are the lengths of equivalent absorption (m)

Therefore, to obtain the Kij values in situ, we measure improvements in the speed between the structural elements. In addition we measure the Reverberation Time of each element. There are procedures based on the mass and other parameters to obtain the Kij values. These procedures are based on laboratory measures and are described in the Norm 10848. The value Kij presented in this work have been obtained in situ for other works.

4 Results

In this paragraph there appear some results of the use of the expressions obtained previously.

Wall Materials	**Code**
Double hollow brick wall 7cm	Wall1
Double gypsum plasterboard (13mm) with mineral wool(double) inside cavity	Wall2
Brick wall 240	Wall3
Double gypsum plasterboard (13mm) with mineral wool inside cavity	Wall4
Hollow brick wall 7cm	Wall5
Floor Materials	**Code**
Reticulated roof space 200+50	Floor1
Reticulated roof space 250+50	Floor2

Table 1. Different combinations and codes assigned

4.1 Vertical Divisions

To value the effect of Kij (and also the next unión) one solution is to choose the parameters that appear in figure 6 in addition to constructive elements in common use. A combination of different cross unions in T in this geometry, and global values are obtained, with the defined procedures in 12354-1. Kij is obtained by the means of the predicted formula or through measurements in situ.

All the values that appear in the tables are dB (A).

It has been considered in any case the same volume of enclosure emission (30m^3).

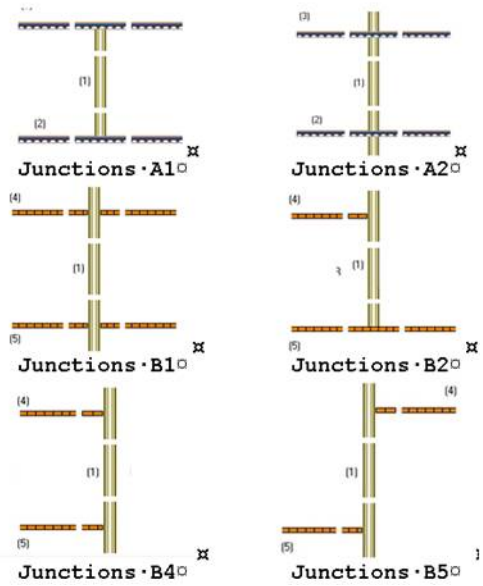

Fig 6. Different types of unions (vertical)

Wall	Floor	Flanking wall	JA1 JB1	JA2 JB2	JA2 JB1	JA1 JB2
Wall 1	Floor 1	Wall 3	49	52	50	51
Wall 1	Floor 1	Wall 4	53	54	53	53
Wall 1	Floor 2	Wall 3	50	52	50	51
Wall 1	Floor 2	Wall 4	53	54	54	53
Wall 2	Floor 1	Wall 3	47	47	46	46
Wall 2	Floor 1	Wall 4	52	50	50	53
Wall 2	Floor 2	Wall 3	47	46	46	47
Wall 2	Floor 2	Wall 4	53	51	50	54

Table 2a. Results of combinations of Figure 7

Wall	Floor	Flanking wall	JA1 JB3	JA2 JB4	JA2 JB3	JA1 JB4
Wall1	Floor1	Wall3	50	52	51	53
Wall1	Floor1	Wall4	53	54	53	53
Wall1	Floor2	Wall3	50	51	51	52
Wall1	Floor2	Wall4	53	54	54	54
Wall2	Floor1	Wall3	47	46	46	46
Wall2	Floor1	Wall4	52	50	50	53
Wall2	Floor2	Wall3	47	46	46	47
Wall2	Floor2	Wall4	53	51	51	54
Wall2	Floor1	Wall5	47	50	47	50
Wall1	Floor2	Wall5	47	50	47	50
Wall2	Floor1	Wall5	40	43	40	43
Wall2	Floor2	Wall5	41	43	40	43

Table 2b. Results of combinations of Figure 7

Wall	Floor	Flanking wall	JA1 JB5	JA2 JB6	JA1 JB7	JA2 JB8
Wall1	Floor1	Wall3	51	51	51	52
Wall1	Floor1	Wall4	53	54	53	54
Wall1	Floor2	Wall3	51	52	51	52
Wall1	Floor2	Wall4	53	54	53	54
Wall2	Floor1	Wall3	46	46	46	46
Wall2	Floor1	Wall4	53	50	53	50
Wall2	Floor2	Wall3	47	46	47	46
Wall2	Floor2	Wall4	54	51	54	51
Wall2	Floor1	Wall5	50	50	50	50
Wall1	Floor2	Wall5	50	50	50	50
Wall2	Floor1	Wall5	43	43	43	43
Wall2	Floor2	Wall5	43	43	43	43

Table 2c. Results of combinations of Figure 7

4.2 Floors

A procedure has been achieved similar to the floor one with the geometry indicate in the fig. 8. In the same way, a combination of unions between + and T.

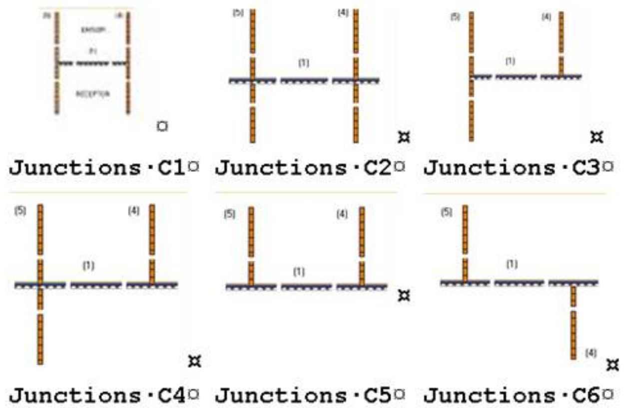

Fig 7. Junctions Code (Floors)

FLOOR	F1	F2	F3	F4	JC1 JC3	JC2 JC4	JC1 JC5	JC2 JC6
Floor1	Wall3	Wall3	Wall3	Wall3	52	53	52	53
Floor1	Wall5	Wall5	Wall5	Wall5	45	50	45	50
Floor2	Wall3	Wall3	Wall3	Wall3	46	51	53	54
Floor2	Wall2	Wall2	Wall2	Wall2	57	58	57	58
Floor2	Wall5	Wall5	Wall5	Wall5	46	51	46	51
Floor1	Wall3	Wall3	Wall2	Wall2	53	55	53	55
Floor2	Wall3	Wall3	Wall2	Wall2	54	56	54	56
Floor1	Wall3	Wall3	Wall5	Wall5	50	50	50	50
Floor2	Wall3	Wall3	Wall5	Wall5	51	52	51	52
Floor1	Wall2	Wall2	Wall5	Wall5	50	51	50	51
Floor2	Wall2	Wall2	Wall5	Wall5	52	52	52	52

Table 3. Results of combinations of Figure 8

5 Conclusions

The DB-HR of the CTE allows two options to ratify a constructive solution. The first option, the simplest, is based upon relatively tight solutions, with a table of generic materials which must have some mínimum specifications.This option doesn't directly take into consideration the effect it can produce by a unión.

The second option, a more detailed method, is a report of values from the laboratory adapting itself to conditions in situ, across (VRI) Kij. This can be obtained in some cases by the equations of predictive Norms and in others, across measured procedures in situ.

When using predictive equations there are certain limitations. On one hand, the equations can only be used with those materials from which they have been obtained. On the other hand, there are other kinds of unions which don't reflect the Norm.

In the case of Kij measurement the following limitations apply. However laboratory test only consider certain combinations of unions and materials [7].

The in situ tests still don't have a Norm of reference and through the measurement of Reverberation Time in each element uncertainty in the values is increased.

Finally, if one analyses the different combination of information, as it has been presented in the previous part, it can be perceived that only by the use of the unión between + and T, can a difference in the Global parameters be produced.

Acknowledgments

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