THE EFFECTS OF DIFFERENT CONCRETE CLASSES OF BARE FLOORS ON FLOOR COVERINGS EFFICIENCY

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ABSTRACT

The characterisation of impact sound insulation of a bare floor is done based on specific tests in accordance with what is established in the appropriate set of international standards. nevertheless, for identical bare floors, to which one might suppose an identical acoustical performance, different response descriptions, in frequency domain, may be obtained if the concrete class at the zone where the impact hammer strikes is different.

In a previous study, some simulations were performed to evaluate the magnitude of these different response descriptions on the impact sound insulation index. but an important question still remains: how do these different descriptions affect the efficacy of coverings? to answer to this question, a study on the influence of different concrete classes on the efficacy of two current floor coverings were done.

An important and fundamental conclusion was reached. These different response descriptions do not affect the noise reduction of a floor covering. The range of these variations are generally of 1 db order.

1. INTRODUCTION

The most frequent sound insulation problems in buildings, are those caused by the transmission of sound energy due to impacts, which resulting from the direct excitation of any partition element may propagate fairly easily, due to the rigidity of the existing junctions, throughout the entire structural grid of the building.

Peoples' movements, falling of objects, dragging pieces of furniture and generally, any impulsive force exerted at a point on an element of a building, produces an excitation that propagates as elastic waves to elements, to which it is connected. This may occasionally cause intensive sound fields, at locations in the building distant from the origin of excitation.

In overall terms, the impact sound may present a more "annoying" character, as regards the acoustic performance of a building, than airborne sound, as Figure 1 qualitatively shows.

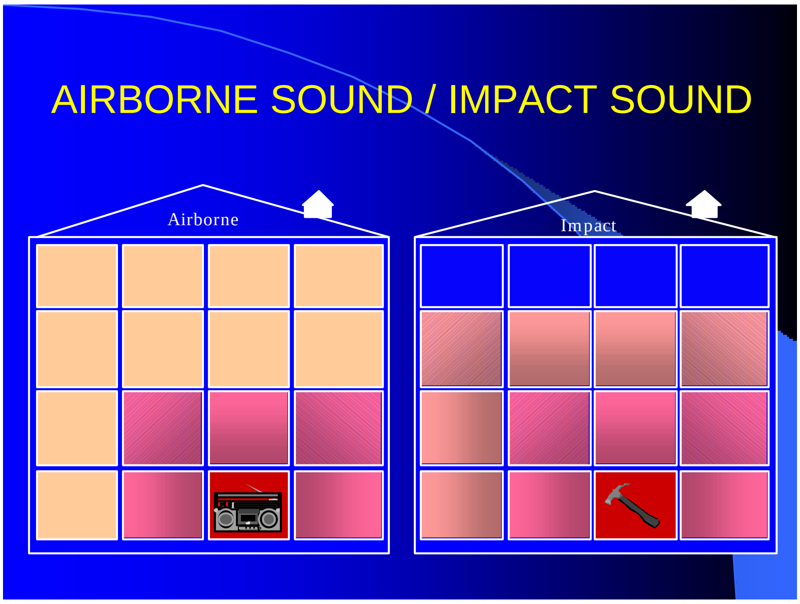

Fig. 1 - *Qualitative influence of airborne and impact sound in buildings*

The noise insulation characterisation of a bare floor regarding impact sound is based on specific tests made in accordance with what is established in the set of appropriate international standards EN ISO 140, parts 6 and 7 [1], and EN ISO 717-2 [2]. Nevertheless, for identical bare floors, to which one might suppose an identical acoustical performance, different response descriptions in frequency domain may be obtained if the concrete class at the zone where the impact hammer strikes is of different class.

In a previous study done by the author - Building Acoustics, Vol. 4, nº 4, 1998 - [3], some simulations on a standard floor were performed to evaluate the magnitude of these different response descriptions on the corresponding impact sound insulation index. But an important doubt still remained. How do these different descriptions affect the efficacy of floors coverings? This aspect seems to be of crucial interest for the community because what people need is to have (and expect) the same performance either at the project stage or on site.

2. EFFECTS OF CONCRETE CLASSES ON THE NOISE INSULATION INDEX OF BARE FLOORS

To evaluate the variations on noise insulation index caused by the use of different concrete classes in the construction of floors, a specific study was developed based on the modelling of the excitation exerted on the floors by the hammer of the tapping machine. The excitation force was obtained by modelling the excitation induced by the standard impact equipment, *i. e.* the Bruel and Kjaer model 3204 the tapping machine. The hammer of the tapping machine constitutes a spherical cap, with a 0,5 m radius, with 0,5 kg mass, in a free fall from a theoretical height of 0,04 m approximately at 10 blows per second (10 Hz frequency).

The contact between hammer and the plane, when there is no interposition of any type of resilient material, is of hertzian type [4] .

$$M\ddot{\varphi} = -F(t) \qquad (1)$$

In accordance with the Hertz relations, one has for the contact between sphere and the plane, the expression:

$$F(t) = K\varphi^{3/2} \qquad (2)$$

in which

$$K = \frac{4}{3\pi}\frac{\sqrt{R_2}}{(K_1 + K_2)}; \qquad \text{com} \quad K_1 = \frac{1-\upsilon_1^2}{\pi E_1} \quad \text{e} \quad K_2 = \frac{1-\upsilon_2^2}{\pi E_2} \tag{3}$$

In this equation: K is the generalized bulk rigidity; ν the Poisson coefficient and E the Young modulus of the materials under analysis (the index 1 refers to the hammer and the index 2 to the plane element). R_2 is the radius of curvature of the head of the hammer. In these circumstances the Equation (1) may be written as follows:

$$\ddot{\varphi} = -\frac{K}{M}\varphi^{3/2} \tag{4}$$

The solution of Equation (4) can be obtained numerically for the various conjugated systems formed by the hammer and by the various classes of concrete currently used in civil construction. The maximum value of the displacement function $\varphi(t)$ and the time of duration of impact τ_{cont} which is extremely important to define the limits of integration of the impact force F(t) in the expansion process can be determined from the following expressions:

$$\varphi_{max} = \left[\frac{5}{4}\frac{M\,v_0^2}{K}\right]^{2/5} \qquad \text{e} \qquad \tau_{cont} = 2{,}94\frac{\varphi_{max}}{v_0} \tag{5}$$

in which v_0 represents the velocity of the hammer at the time of contact with the plane.

This periodical function of period T was developed in a Fourier series, which has the following configuration:

$$F(t) = \frac{A_0}{2} + \sum_{n=1}^{\infty} A_n \cos\left(2n\pi\frac{t}{T} - \Phi_n\right) \tag{6}$$

and in which $A_n = \left(a_n^2 + b_n^2\right)^{1/2}$ and $\Phi_n = \text{arc tg}(b_n/a_n)$.

Figure 2 shows the impact forces for the hammer on types of concrete of class C12/15 to C30/35, using values of the bulk modulus prescribed in the regulations, as well as for the two levelling layers with modulus of elasticity (at 28 days) of 15 and 20 GPa respectively. Figure 3 shows the corresponding spectra of the effective force, in third frequency bands.

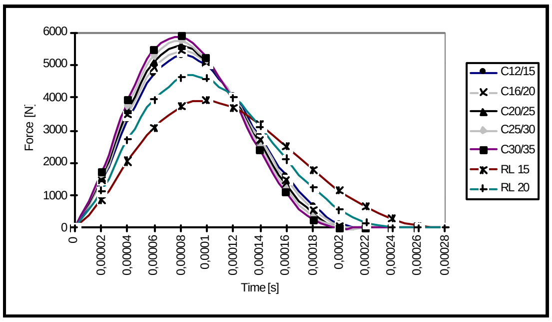

Fig. 2 - *Descriptions of the impact of the hammer on types of concrete of classes C12/15, C16/20, C20/25, C25/30 and C30/35, and on two regulating layers*

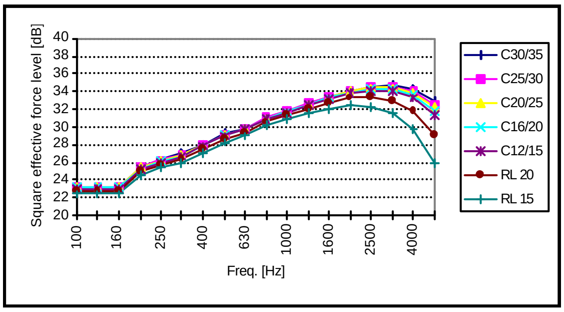

Fig. 3 - *Spectrum of the level of the square of effective force produced at the time of the impact of the hammer on the various types of concrete and on the regulating layers.*

In Table 1 the structure borne noise insulation index values obtained for these concrete classes, for an homogeneous slab of 0,10 m thickness, is shown.

Table 1 - *Noise insulation index for impact sound*

Concrete class	Ln,w (dB/oct.)
C12/15	90,7
C16/20	90,9
C20/25	91,1
C25/30	91,3
C30/35	91,4
Reg. layer (E=15 GPa)	88,3
Reg. layer (E=20 GPa)	89,7

The effect of the concrete class on impact noise insulation is only of the order of 2 dB, and this is for frequency bands greater than 2500 Hz. This is also the case for the impact noise insulation index. In the case of structural concrete with a levelling layer suitable for floor covering, the effect is greater, possibility reaching 5 to 7 dB, in the same frequency bands. This may cause significant variations in the impact noise insulation index. More important is, wether levelling layers are applied to structural concrete floors, they may change the conformity of the impact sound insulation for a certain building, in terms of limits imposed by national regulations.

The class of concrete used at the surface on which the tapping machine is located, has a significant influence on the sound level established in the receiving acoustic space. The lower the modulus of elasticity of the concrete considered, the lower the maximum force applied and the higher the impact time. This means lower amplitudes for the force components at high frequency bands and a consequent increase in those amplitudes for the low frequency bands.

But now what influence can be expected in terms of floor coverings efficiency. Do these differences affect their performance? To answer to this question, two typical floor coverings, one hard, mainly made of wood, and other one softer, made of cork, were tested on those force spectra to verify the alterations of their reduction efficiency.

3. EFFECTS OF FLOOR COVERINGS

It is of common knowledge that the floor coverings may contribute significantly to the reduction of impact noise [5,6]. That reduction derives from the increase in the time of impact of the excitation action induced with coverings applied on the bare floor (which is significantly higher than the time of impact exerted on the same floor, when it is not covered). That increase in the time of impact is assumed to extend the excitation spectra induced on the supporting slab – which is normally the very pavement – therefore causing, on the one hand, the shifting of impact energy towards the low frequency range and changing, on the other hand, the amplitude of the force components that integrate the spectrum.

A typical time description of a shock on a rigid surface (concrete/slab) and on a floor covering is illustrated in figure 4. As can be observed there is a redistribution of the force applied. Thus, it maintains (few times increases) the amplitude of the force components in the low frequency range and significantly decreases the amplitude components in the high frequency zones.

Figure 5 shows a qualitative comparison of the square of the effective value of the force components transmitted by the hammer of the tapping machine on the same pavement, when it is not covered and when it is covered with a floor screed.

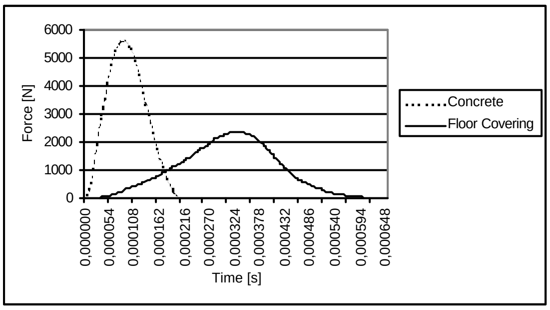

Fig. 4 – *Time descriptions of a impact action on a rigid surface and on a floor covering*

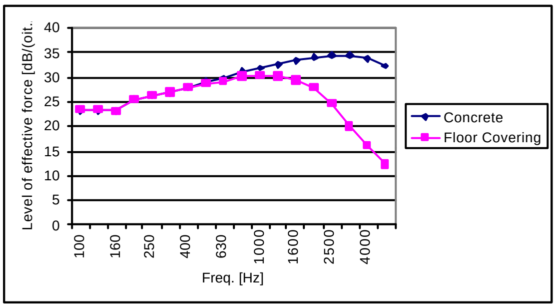

Fig. 5 – *Force transmitted by the standard impact action on the same floor, when it is covered and when it is not covered*

4. DESCRIPTION OF COVERINGS USED

The two floor coverings used in this work have been chosen among a set of coverings that are available on the Portuguese market. For this purpose, two types of coverings have been chosen from among those available for test; one very resilient (cork covering) and other less resilient (wood covering). Figure 6 present schematic cross-sections of the coverings used, indicating the materials used and the thickness of the respective layers.

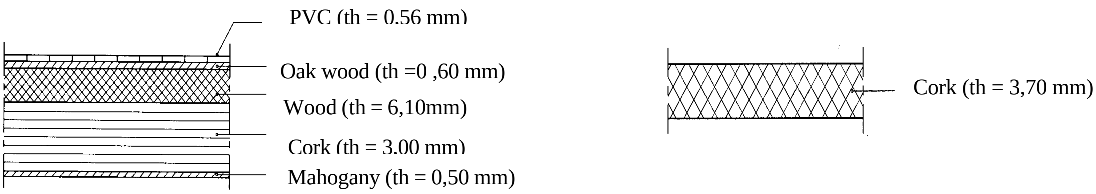

Figure 6 – *Schematic cross-section of coverings used: hard C_1 and soft C_2*

5. TESTS

On each of these different concrete floors the two coverings were applied in order to evaluate their performance and acoustic efficiency [7]. Because sometimes the floor coverings are applied adherently and other times merely placed over the floor, the efficiency of these samples samples were calculated glued and not glued. Nevertheless, to evaluate unwanted possible discrepancies a process of assessment on the difference between their acoustic performance in both situations was carried out. This aspect was evaluated with two tests done on an homogeneous heavyweight standard floor of 14 cm thickness. The following figures 9 and 10 illustrate the comparisons.

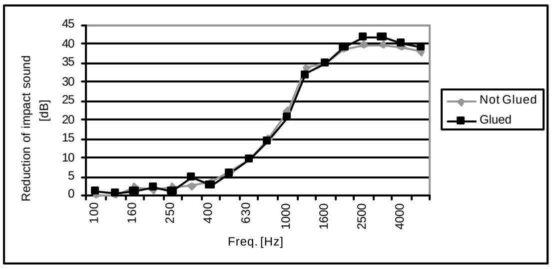

Fig. 9 – *Comparison between the descriptions of noise reduction obtained in the test using cork covering glued and not glued.*

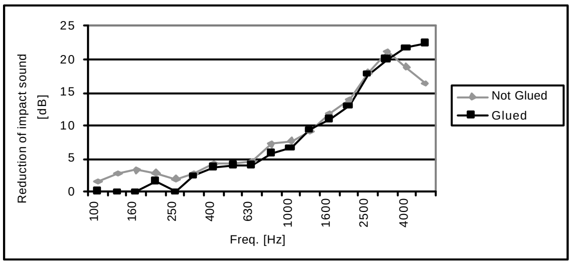

Fig. 10 – *Comparison between the descriptions of noise reduction obtained in the test using wood covering glued and not glued.*

As can easily be verified the difference between the performance of these two coverings both in frequency domain and as unique value (index) is very small. And for these tests the values of Ln,w for bare and covered floor were, in figure 9: 72,6 dB and 72,5 dB (ΔLn,w = 0,1 dB), and figure 10: 78,8 dB and 78,1 dB (ΔLn,w = 0,7 dB).

So, finally, in Table 2 the values of the corresponding efficiency for all cases are presented. From these values is possible to conclude that the differences in concrete class do not affect the efficiency of the floor coverings.

Table 2 – *Efficiency values obtained for all cases*

Concrete Class	Floor Covering	Efficiency (dB)	
		Glued	Not glued
Regulating Layer 1	Wood	13	12
	Cork	21	21
Regulating Layer 2	Wood	13	13
	Cork	22	22
C12/15	Wood	12	13
	Cork	21	22
C16/20	Wood	12	13
	Cork	21	21
C20/25	Wood	13	12
	Cork	21	21
C25/30	Wood	13	13
	Cork	22	22
C30/35	Wood	13	13
	Cork	22	22

6. CONCLUSIONS

From these values is possible to conclude that the differences in concrete class do not really affect the efficiency of the floor coverings calculated based on laboratory standardised tests. They are generally of 1 dB order. However, some discrepancies between values for the same floor covering in laboratory and *in situ* could occur due to flanking transmission. It is possible that when performing calculations to rate bare floor this transmission do not influence the impact insulation index, whilst when calculating the same index for a covered one it could do it so [8].

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