HOW TO QUANTIFY THE REAL IMPROVEMENT OF IMPACT NOISE INSULATION?

Reference PACS: 43:55.Ev

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ABSTRACT

This paper presents some case studies performed on identical horizontal beam and pot floors, in laboratory and on site, using the same floor coverings, which have shown some differences in the values obtained for the calculation of each floor covering real efficiency in all these situations. thus, a comparison analysis on which kind of index could be more appropriate for this characterization was done. This comparison was done using the following indices: the ∆db(a); the ∆ln,w (or ∆l´n,w – when on site); and the difference of loudness level. some conclusions and perspectives for further investigation on this subject are indicated.

1. INTRODUCTION

It is of common knowledge that the floor coverings may contribute significantly to the reduction of impact noise. 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). The increase in the time of impact is intimately related with the elastic characteristics of the floor covering considered.

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.

That situation is similar to the one verified for the impact of the hammer on different types of concrete (see the corresponding study concerning the characterisation of the impact force presented in a previous paper [8]). Attention should be paid however to the fact that the energy transmitted by the tapping machine, in each impact, remains unchangeable, both in the case of covered floor and in the case of uncovered floor, considering that the physical and dynamic characteristics of the fall process remain also unchangeable: the hammer is the same and falls from the same height.

A typical time description of a shock on a rigid surface (concrete/slab) and on a floor covering is illustrated in figure 1.

Figure 2 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.

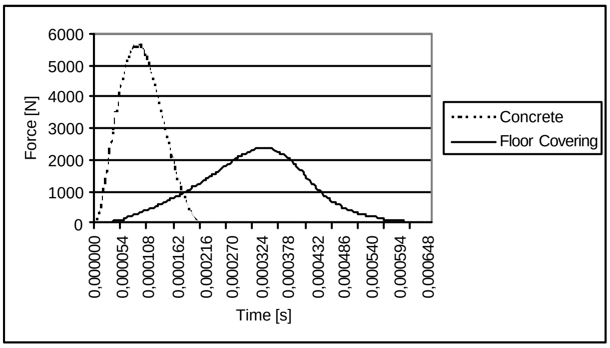

Fig. 1 – *Time descriptions of a impact action on a rigid surface and on a floor covering*

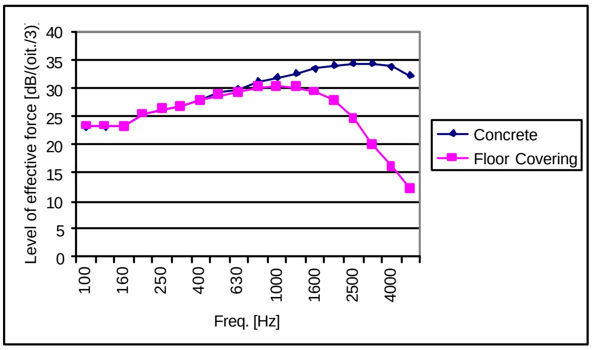

Fig. 2 – *Force transmitted by the standard impact action on the same floor, when it is covered and when it is not covered*

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 of that force in the high frequency zones.

2. DESCRIPTION OF COVERINGS USED

The floor coverings used in this work have been chosen among a set of coverings that are available on the Portuguese market. On the one hand, the proposition of solutions of floor coverings formed by various layers of different materials has become increasingly common and, on the other hand, the acoustic performance of these coverings has not been yet extensively studied.

Figures 3 to 7 present schematic cross-sections of the various coverings used - which are designated as coverings C_I - indicating the materials used and the thickness of the respective layers.

Figure 3 – *Schematic cross-section of coverings C_1 and C_2*

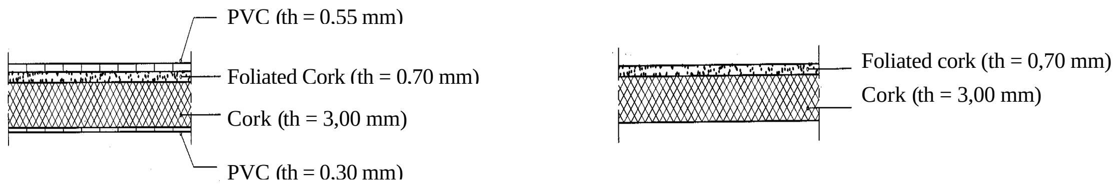

Figure 4 - *Schematic cross-section of coverings C_3 and C_4*

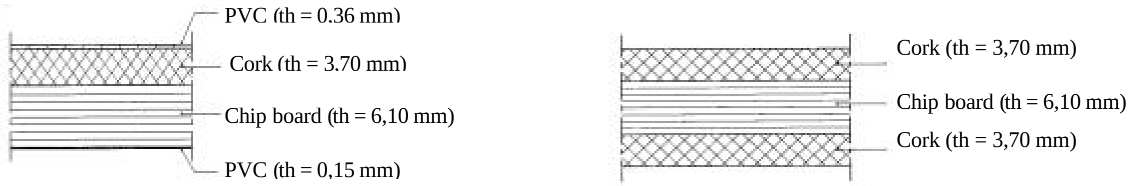

Figure 5 - *Schematic cross-section of coverings C_5 and C_6*

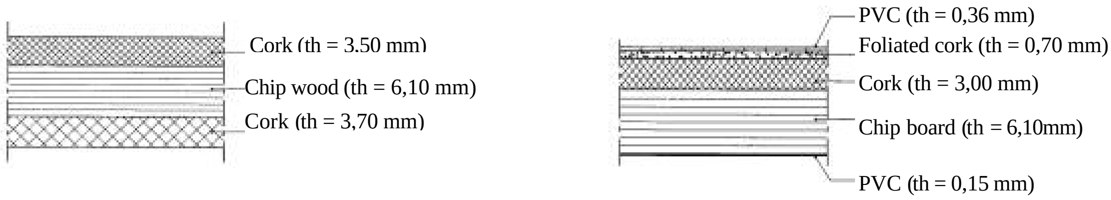

Figure 6 - *Schematic cross-section of coverings C_7 and C_8*

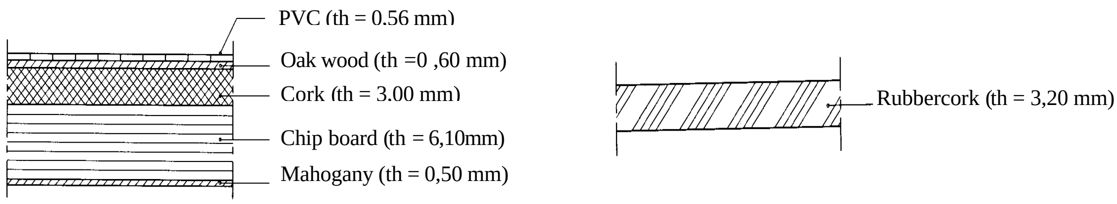

Figure 7 - *Schematic cross-section of coverings C_9 and C_{10}*

3. TESTS

3.1. Introduction

The tests concerning the evaluation of the floor coverings efficiency were performed on identical beam and pot floors. One in laboratory and three on site. A cross-section of the floors used is illustrated in figure 8. It had 25 cm thickness in what respects its structural configuration and a regulating layer of 4 cm.

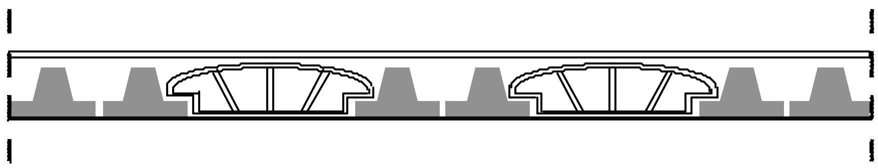

Figure 8 – *Cross-section of the beam and pot floor used*

On each of these floors the set of coverings indicated in figures 3 to 7 were applied in order to evaluate their performance and their acoustic efficiency. Because the same samples were needed to perform tests in laboratory and on site, the tests had to be done with the samples not glued. So, it was necessary to assess the difference between their acoustic performance when they are glued to the slab and when they are merely placed over it. This aspect was evaluated with two tests done on an homogeneous heavyweight standard floor of 14 cm thickness. 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). The following figures 9 and 10 illustrate the corresponding comparisons.

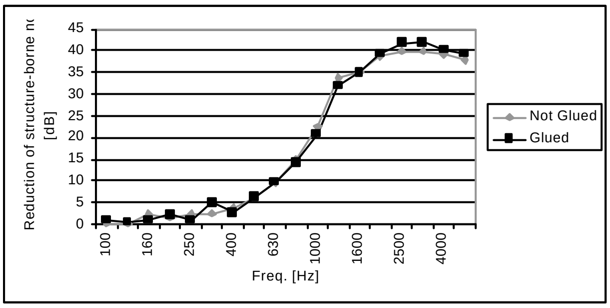

Fig. 9 – *Comparison between the descriptions of noise reduction obtained for the test of the cork covering, either glued or not glued.*

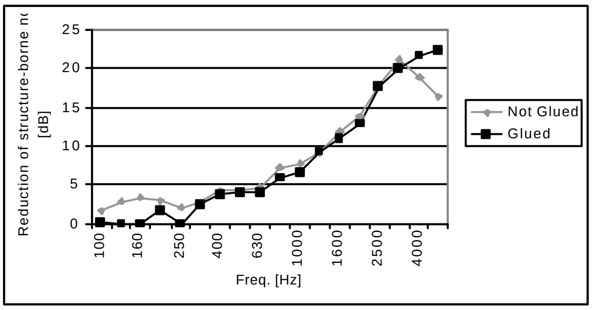

Fig. 10 – *Comparison between the descriptions of noise reduction obtained for the test of wood covering, either glued or not glued*

As can easily be verified the difference between the performance of this two coverings both in frequency domain and in unique values (index) is very small.

3.2. Laboratory and on site conditions

The laboratory tests have been performed in the reverberation room existing at the National Laboratory for Civil Engineering (LNEC). The characteristics of the room correspond to the type of facility prescribed by EN ISO 140-1. It has 120 m^3 volume.

The building where the tests have been carried out is characterised by a construction in height, with repetition of the same type of structure and division along the 6 floors. The 2nd floor beam and pot slab has been chosen for this purpose.

3.3 . Results obtained

Table 1 presents the values of the improvement in transmitted impact noise of all floor coverings, tested in laboratory and on site.

Table 1 - *Values of the reduction of transmitted impact noise obtained for the coverings tested*.

Covering	Efficiency of the floor coverings (dB/(oit./3))			
	Lab.	Room 1	Room 2	Room 3
C_1	11,5	13,1	19,2	20,5
C_2	21,5	24,9	30,1	30,5
C_3	9,9	9,5	17,0	18,0
C_4	18,3	19,6	24,9	28,2
C_5	20,0	23,7	30,8	24,9
C_6	23,8	26,3	31,9	26,9
C_7	26,9	16,3	31,6	34,6
C_8	19,3	21,5	24,3	24,8
C_9	18,9	18,4	31,3	22,6
C_{10}	19,7	21,6	25,4	26,0

As can be seen for the same sample, the calculated noise reduction index is different from laboratory conditions to on site conditions as well as between the rooms of the building tested. At first sight, this situation seems to be very strange because what one should expect would to find similar values for the reduction indices of the same sample. However, this fact does not appear to be very dramatic when one is applying a floor covering to comply the impact sound insulation index of a global partition system - which includes the very pavement with the covering applied - with the national regulations. This is because, if the values determined in laboratory conditions were used, it is possible to comply them in most part of the cases.

Nevertheless, the results obtained and presented in table 1 become worrying considering that the range of coverings tested includes the most sold nowadays. This may cause many problems in real situations, because what people need is to have (and to expect) the same performance either at the project stage or on site. Having in attention this problem was decided to verify which would be the best index to use in order to suitably describe the floor coverings performance. To do that, the results obtained with the tests done in all situations, in laboratory and on site, were used. The parameters adopted to evaluate this aspect were respectively the noise reduction index calculated in accordance with the EN ISO 717-2, by octave bands using the spectra extended to 5 kHz. By third octave bands using in one case the spectra extended to 5 kHz, and in the other to 3150 Hz. The dB(A) parameter, using the spectra extended to 5 kHz and 3150 Hz, was also used as well as the Loudness Level parameter. Figures 11 to 20 illustrate the comparison of the indices calculated for each floor covering and for each site where the tests were performed. In the figures the category axis *xx´* is in accordance to the one presented in table 2.

Table 2 – *Category of xx´ axis for figures* 11 *to* 20

Number of category	Category *xx´* axis
1	ΔLoudness level (sone)
2	ΔLn,w (dB/oit.) - 5kHz
3	ΔLn,w (dB/(oit/3)) - 5 kHz
4	ΔLn,w (dB/(oit/3)) – 3150 Hz
5	Δ Ln,w dB(A) - 5 kHz
6	Δ Ln,w dB(A) - 3150 Hz

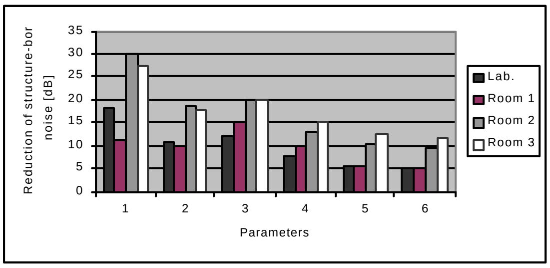

Fig. 11 – *Comparison for covering* C_1

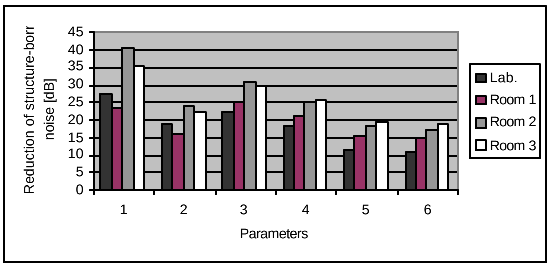

Fig. 12 – *Comparison for covering* C_2

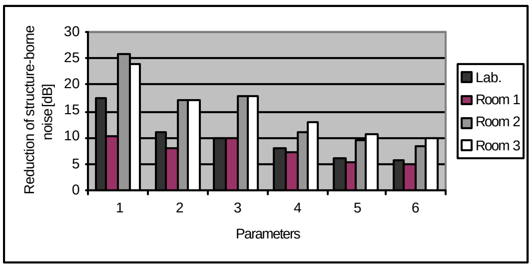

Fig. 13 – *Comparison for covering* C_3

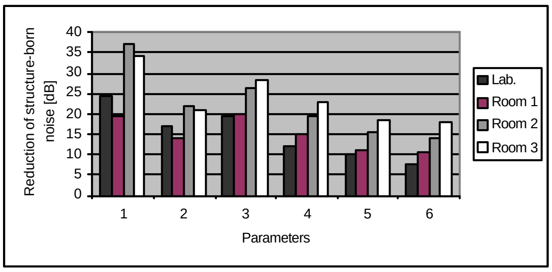

Fig. 14 – *Comparison for covering* C_4

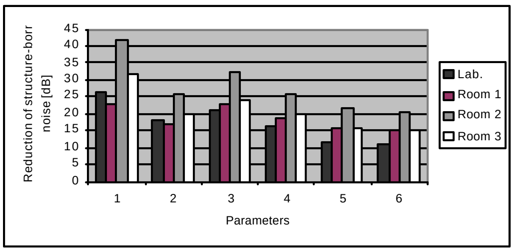

Fig. 15 – *Comparison for covering* C_5

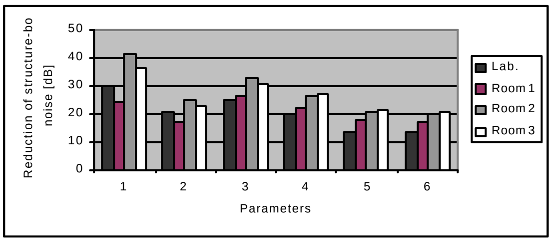

Fig. 16 – *Comparison for covering* C_6

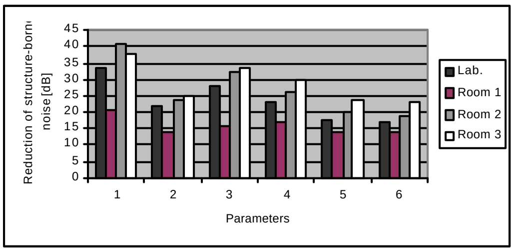

Fig 17 – *Comparison for covering C_7*

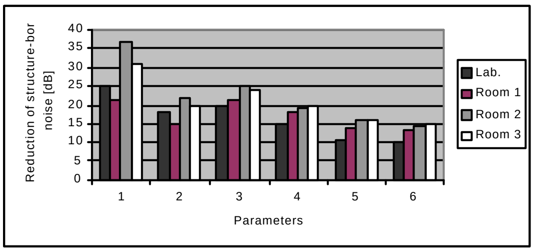

Fig. 18 – *Comparison for covering C_8*

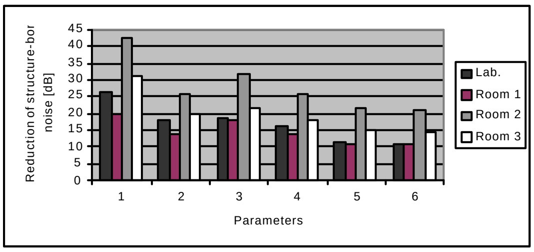

Fig. 19 – *Comparison for covering C_9*

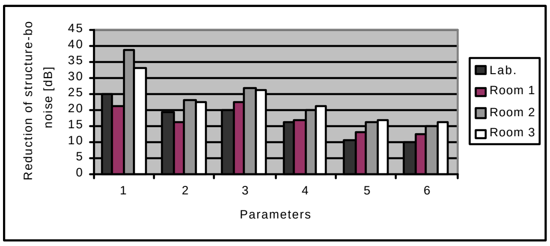

Fig. 20 – *Comparison for covering C_{10}*

In order to evaluate which index should be more acceptable to diminish the discrepancies that occur between the results obtained in laboratory and on site, the average differences between each room results, in terms of reduction of impact noise, and the laboratory value (the laboratory value was taken as the base), for each parameter considered in this analysis, were calculated as well as the respective standard deviation of those differences. The resulting values are indicated in figure 21.

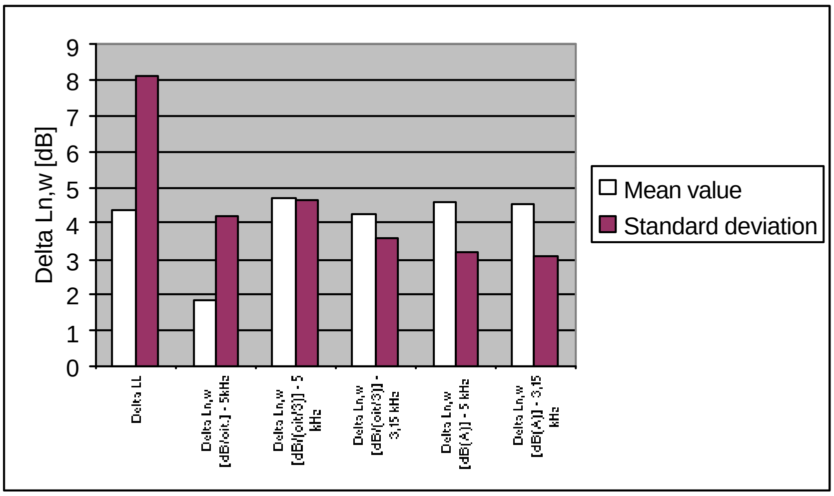

Fig. 21 – *Average and standard deviation between the impact noise reduction on site and in laboratory*

4. CONCLUSIONS

Based on the tests performed and on the values illustrated by figures 11 to 20, as well as in figure 21, appears to be most suitable the use of the dB(A) index to characterise the acoustic performance of floor coverings. This parameter is less sensitive to the variations originated by the use of different zones of the response spectra in the calculation of the indices and to the effects of reducing the range of the spectra.

The ΔLn,w as it is described by the EN ISO Standard 717-2, has a failure, which lies in the fact that, when one intends to rate the real efficiency of floor coverings in situ using the difference between the indices calculated for bare floor and for covered floor, he considers, in each case, different floor responses. Apart the fact that the housing buildings do not have standard floors, the respective dwellers need to have their acoustic comfort requirements accomplished.

The discrepancy between values for the same floor covering in situ may be due to flanking transmission. It is possible that when performing the calculations for rating the bare floor this aspect do not influence the impact noise insulation index, whilst when calculating the same index for a covered floor it will be then considered. This problem is obviously softened with the dB(A) parameter.

Having in attention that the tests were performed with the samples not glued, probably one might say that the differences could be originated by the behaviour illustrated, mainly in figure 10. However, the most part of the samples used were highly resilient and 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, it is opinion of the authors that it is urgent the development of further research on this subject, studying the influence of flanking transmission in the rating of acoustic efficiency of floor coverings and investigating the possibility to find a suitable and an ambiguous index to charaterise this performance.

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