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EVALUATION THE CAPACITY OF ACOUSTIC ISOLATION OF A COMMERCIAL AND REGIONAL MATERIALS FOR THE IMPACT NOISE ISOLATION

Bruno Alberto Cardoso Pignatario[1]

Wagner de Sousa Santos

Carolina de Oliveira Contente

Gustavo da Silva Vieira de Melo

Universidade Federal do Pará
[1]Bruno.pignatario@gnail.com

Abstract. *Since the 2013 has been approved the new rule performance in buildings, NBR 157575, the standard have one item for acoustic evaluation, and to evaluate the capacity of acoustic isolation of a commercial and regional materials for the impact noise isolation. The present study has been realized using an industrial and regional acoustic insulation. The tests have done with reverberant chamber in scale and the samples of concrete slab for simulate the rea l building. The results, when compared with the NBR 15575 standard show that the levels of impact noise are in an allowed level for the commercials materials and the regionals materials.*

Keywords: *Acoustic Isolation, Impact Noise, Reverberant Chamber, Concrete Slab, NBR 15575.*

1. INTRODUCTION (TIMES NEW ROMAN, BOLD, SIZE 10)

The noise is one of the non-desirable elements for those who wants a quiet and stimulating environment for the daily activities development, in residential or commercial buildings. However, in most cases, when buying a realty, the client worries about other factors, as for example, the cost and the size of the environments, forgetting the acoustic comfort in the realty. In this case it has the impact noise, also known as structural noise, which is related to sound propagation by the impact of objects with existing materials in the environments according to Jeon *et al*. (2002), the noise is considerate as the most annoying between the noises in several residential buildings floors around the world.

Aiming to increase the search by the builders by materials for noise control, there is the possibility of using alternative materials, basing in raw materials present in the region. In this respect the POLOPROBIO arises (Protection Pole of Biodiversity and Sustainable Use of Natural Resources) as a project, which mission is to promote economic and social growth of traditional communities and indigenous people of the Amazon, aiming to Sustainable Regional Development to environmental protection and the promotion of the human being through the management and native latex processing to manufacturing rubberized covers.

Acoustically isolate an environment is a very complicated task considering that human reactions to noise are subjective. However, mitigate its impact has been one of the great goals of construction in recent years, especially from 2008, with the publication of NBR 15575, by the Brazilian Association of Technical Standards (ABNT) which came into force in 2013 and forced companies to be concerned with the acoustic comfort of the environments, as well as other requirements that are not part of this study. Thus arises the need for professionals in the construction industry and the acoustics area to deepen over structural noise control.

The structural layer is formed, generally, by concrete slab. Over it, a layer of thermal or acoustic insulation is placed as seen in this study, it can be formed by various types of resilient materials. Finally, there is the workmanship that is formed, for example, subfloor and ceramics.

After the implementation of NBR 15575, companies in the construction sector have to adapt to the parameters established by this standard and should seek alternative technologies using local materials for example, that will contribute to the impact noise isolation in floors between the apartments.

The object of study of this work is to verify the possibility of using latex blankets as a way to control the propagation of impact noise, simulating an apartment floor system, making a comparative analysis with the values established by the standard.

2. METHODOLOGY

The methodology used has its base extracted of the work of Braga *et al* (2013) who studied the latex isolation potential for impact noise between floors. Tests were made in the laboratory using ISO 140-7 to analyze the noise spectrum per frequency band and ISO 717-2 that provides the standard curve for adjustment of the values obtained in the experimental analysis. The default values of performance in buildings are then compared to the standardized for the NBR15575 (2013) and classified, according to this, in minimum, intermediate and superior performance range. The values adopted are shown in Tab. 1 below.

Table 1. Weighted standardized impact sound pressure level and the respective development classification for the NBR 15575 (2013).

Element	$L'_{nt'w}$ (dB)	Performance levels
Floor system separating autonomous housing units positioned at different floors.	66 to 80	Minimum
	56 to 65	Intermediate
	≤55	Superior

To determine the number of samples of acoustically insulating blankets to be studied in this research, it is first important to define the universe of possible mixtures to be made considering two types of composition for each mixture. As was available four types of compositions for producing the webs, the universe can be obtained by a simple combination as Equation 1:

$$C_{n,p} = \frac{n!}{p!(n-p)!} \qquad \text{Eq. 1}$$

Where:

n is the total number of elements p number of elements combined.

So, for the values:

$$C_{n,p} = \frac{4!}{2!(4-2)!} = 6$$

Because there two analysis thicknesses (3 mm and 5 mm), the universe of possibilities results in 12. Taking into account the possibility of using only a mixture for the blankets, we arrive at the result of the possibility of 16 samples universe. Importantly, one of the five mixtures (açaí stone gray) was not considered in these calculations as this was used in all the blankets, because contribute to the consistency of the mixture.

As research in the field of latex blankets are not very widespread so far, it was randomly chosen based on the work used for this research as theoretical basis the standard deviation, margin of error and confidence level. Thus, one can determine the number of samples required for this research by Equation 2:

$$n = \left(\frac{Z_{\frac{\alpha}{2}} * \sigma}{E}\right)^2 \qquad \text{Eq. 2}$$

Where:

$Z_{\frac{\alpha}{2}}$ is the critical value that corresponds to the desired confidence interval, 1.96 to be confidence level of 95%. σ is the standard deviation considered and 8% for this case, and E is the margin of error, 5% for this study. With this, the equation two it is expressed as:

$$n = \left(\frac{1.96 * 0.08}{0,05}\right)^2 = 10$$

Thus it was obtained the total of 10 samples for the experiment. Was statistically determined a set of ten samples made using latex mixtures with various stabilizers, shown in Tab. 2. The amounts were obtained during the production of blankets, according to amounts that the members of the project have worked empirically to obtain the adequate mixing.

Table 2. Composition of the blanket's mixtures.

Componentes	Blanket 1		Blanket 2		Blanket 3		Blanket 4		Blanket 5	
	3 mm	5 mm	3 mm	5 mm	3 mm	5 mm	3 mm	5 mm	3 mm	5 mm
Latex (l)	3	3	3	3	3	3	3	3	3	3
Mixed wood dust (g)	250	500	100	200	-	-	100	200	200	400
Ash of açaí (g)	50	50	50	50	50	50	50	50	250	250
Minced fiber of açaí (g)	-	-	250	500	100	200	-	-	-	-
Fiber of açaí seed(g)	-	-	-	-	250	500	250	500	-	-
Paricá wood dust (g)	-	-	-	-	100	200	-	-	-	-

The mixture of the blankets was done manually with artisanal preparation, as shown in Fig. 9 A and B. The latex mixture was applied on a thin sheet of aluminum so the sizes were standardized and the manufacturing was made in layers, following the dynamic of the application, drying and reapplying of the layers until the desired thickness was reached.

Figure 2. (A) Application of mixed and (B) spreading the mixed latex above the aluminum plate.

Besides these samples, other materials presented on the market have been tested, among these three blankets of material made based on recycled tire with a thickness of 3 mm, 5 mm and 8 mm, being these samples provided by a consolidated company in the control of the noise impact market, which in this research will be called company A. Besides these materials, were also analyzed two samples with 5 mm thick made of polymers, from another company that will be named as company B.

To make the results as close as possible to reality, a concrete floor sample with 10 mm thickness and 60 x 60 cm in size was used. The choice of concrete sample was because this floor system is used in most buildings.

In the tests were used a sound pressure level analyzer type 2260 along with the diffuse field microphone 4189 and his calibrator type 4231, both manufactured by Brüel & Kjaer .

Additionally were used a scaled reverberant chamber, a tapping machine 3207, responsible for generating the impact to be analyzed, a dodecahedral source type 4296 and a pre-amplifier type 2716, also manufactured by Brüel & Kjaer mounted as shown in Fig. 3 A. In Figure 3 B is shown a montage of the slab on the reverberation chamber with the tapping machine, setting the mounting template for testing.

Figure 3. (A) Setup of the equipment into the reverberation chamber and (B) position of tapping machine above the concrete slab.

It was first analyzed the isolation noise impact only the in the sample of the concrete floor, to check the influence of the subsequent measurement results with the latex blankets and the industrialized material.

After that, it was measured the level of isolation to the impact noise with latex blanket samples over the concrete floor. The procedure performed with latex blanket samples was repeated with the industrialized materials blankets provided by the companies in the sector. Importantly, during rehearsals, due care has been taken in relation to leveling the tapping machine, which, if not properly correct, can influence the results, due to the fact that modifies the characteristic of the hits, influencing the generated noise.

Computational and experimental modal analysis of the slab with and without the addition of the blanket was performed. This was done because, according to Soeiro (2001), it is a process by which you can check the influence of the damping on the noise isolation behavior.

Thus, the face of the slab was divided into equally spaced nodes, which would completely sweep its area. For the tests, were used the impact hammer PCB 086C03 (Fig. 4 A) as excitement, the accelerometer PCB 352B68 (Fig. 4 B) sensitivity of 104.5 mV/g, with frequency range of 1 to 7000 Hz for signal acquisition, together with the signal analyzer B & K Pulse 3560C.

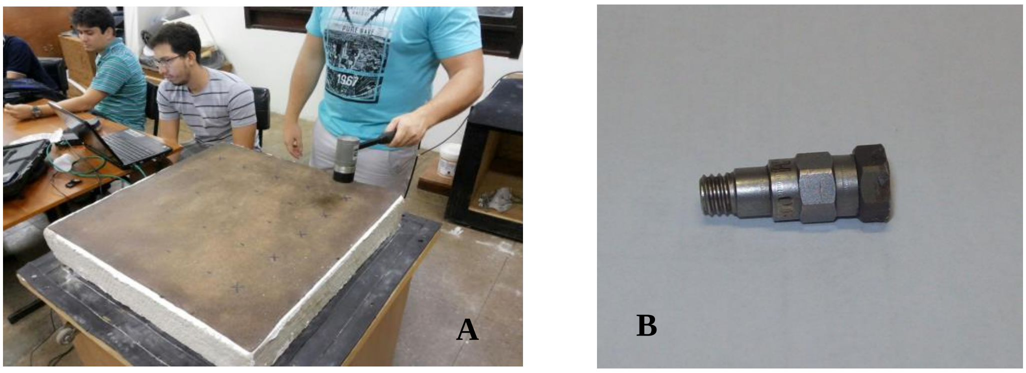


Figure 4. (A) Execution of the modal analysis and (B) accelerometer used.

3. RESULTS

3.1 Analysis of sound pressure level per frequency band

After performing tests on samples of latex and industrialized blankets, the results by frequency band were obtained, as shown in Figs. 5 to 7.

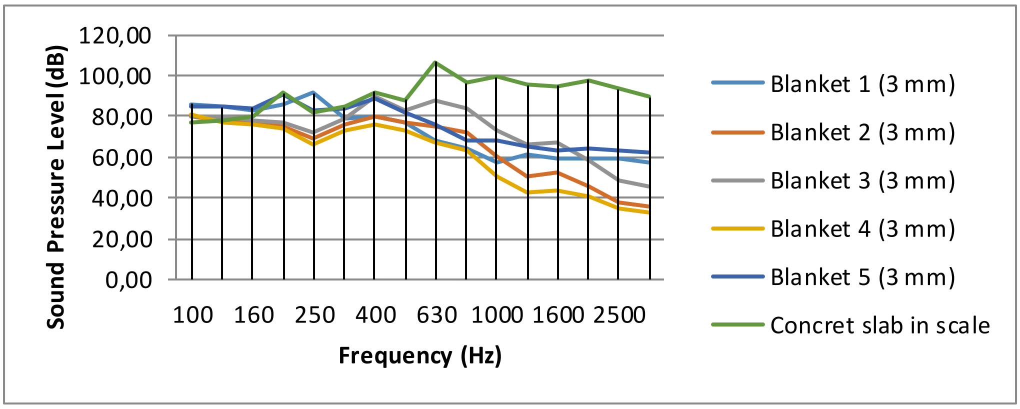


Figure 5. SPL results for the blankets of 3 mm.

Through the results obtained, it can be noticed that the decay of the sound pressure level generated by the impact of the tapping machine was considerable in all the analyzed blankets, from the average and especially of high frequencies, as shown in Fig. 5, and the blanket that showed the best results was the blanket 4, which obtained approximately 14 dB reduction of impact noise level in the frequency of 500 Hz, and at high frequencies (1000 to3150 Hz) an average reduction of the impact noise of 54 dB. At low frequencies (100 to 250 Hz), the reducing average was 13 dB.

The 5 mm blankets had similar results (see Fig. 6), presenting, on average, a reduction of noise impact of 11 dB in the range of 500 Hz. At higher frequencies, reducing average of these was approximately 51 dB and in the low frequencies, 11 dB.

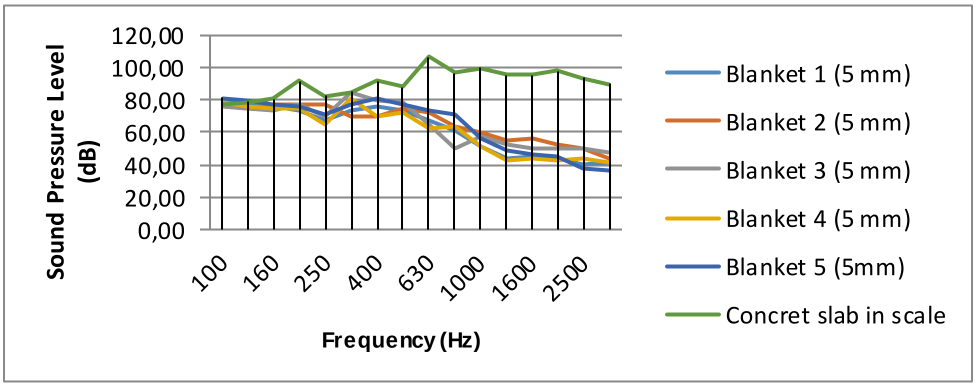


Figure 6. SPL results for the blankets of 5 mm.

In the analysis of industrial materials provided by companies of the sector shown in Fig. 7, it was observed that the sample that achieved the best results was the one made with recycled tire with a thickness of 8 mm, with reduction of 15 dB in the frequency of 500 Hz and average reduction, in the higher frequencies, of 48 dB.

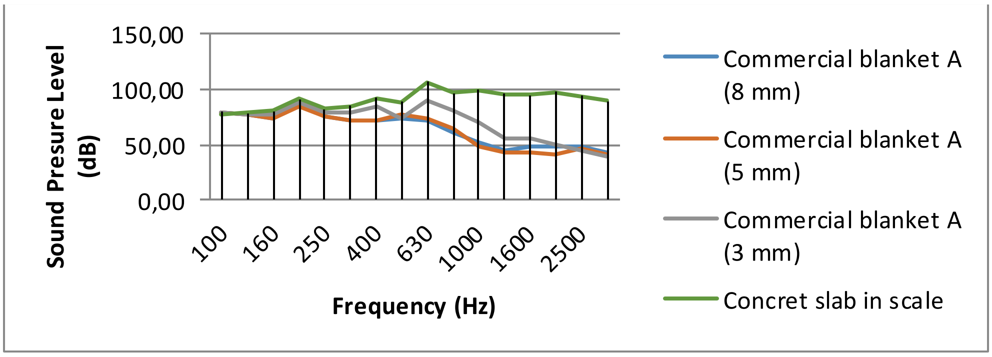


Figure 7. SPL results for the commercial blankets.

Standardized and weighted values used for comparison with the standard of performance, NBR 15575, are shown in Tab. 3.

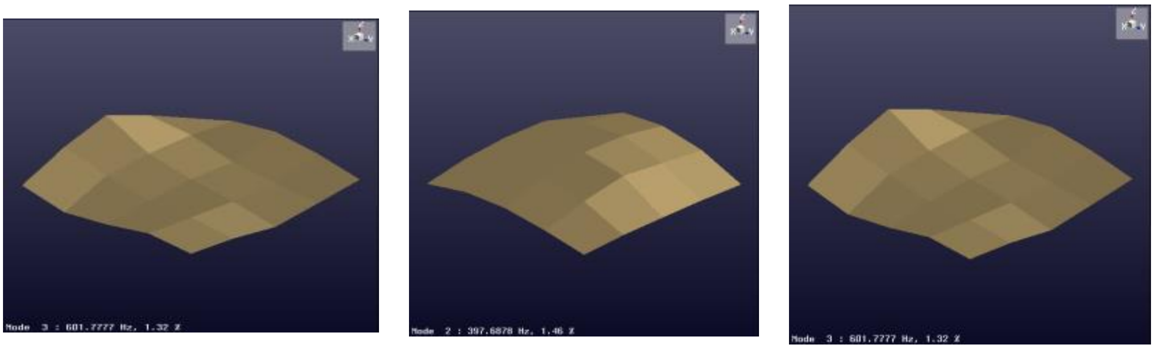
Table 3. Lnt'w compared with the NBR 15575 standard

Sample	Lnt'w (dB)	Performance
Blanket 1 (3 mm)	70	Minimum
Blanket 1 (5 mm)	69	Minimum
Blanket 2 (3 mm)	73	Minimum
Blanket 2 (5 mm)	70	Minimum
Blanket 3 (3 mm)	77	Minimum
Blanket 3 (5 mm)	71	Minimum
Blanket 4 (3 mm)	70	Minimum
Blanket 4 (5 mm)	69	Minimum
Blanket 5 (3 mm)	80	Minimum
Blanket 5 (5 mm)	73	Minimum
Commercial blanket A(8 mm)	71	Minimum
Commercial blanket A(5 mm)	72	Minimum
Commercial blanket A(3 mm)	78	Minimum
Concret Slab	102	Not apply

It is noticiable that the blankets that had best results were the blankets 1 and 4 with 5 mm of thickness; however, it is important to note that in these two blankets were obtained differences between the measured curves and reference curves from ISO 717/2 in 8 dB. Regarding the samples of industrialized materials, the blanket that had the best result was the one from company A with 8 mm of thickness.

3.1 Modal analysis of the slab

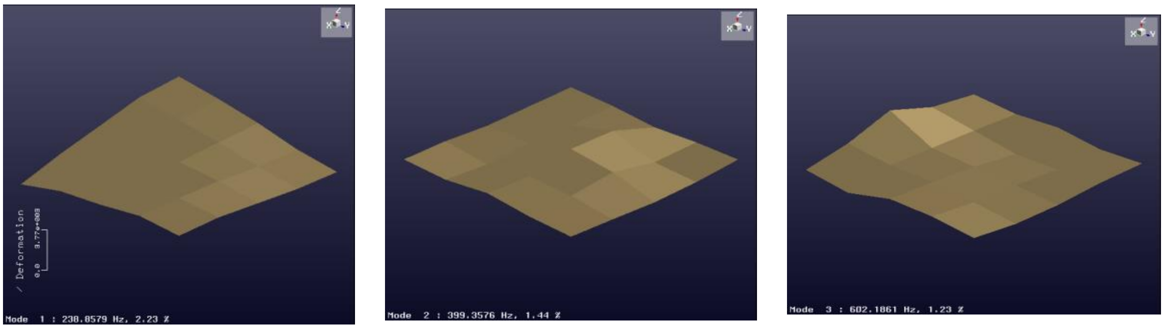
As the analysis of the sound pressure level has shown that the blanket 1 and 4, both of 5 mm of thickness, had equivalent performance, modal analysis between these and the blanket of Company A of 8 mm of thickness was performed. Both samples showed the best performance as the sound pressure level. In addition, with the modal analysis the influence of damping can be checked. Figs. 8 to 10 show the modal behavior of the tested samples obtained in the software Testlab, together with the experimental results obtained in PulseLabshop.



Frequency 243.82 Hz	Frequency 397.688 Hz	Frequency 601.78 Hz
Damping factor 1.71%	Damping factor 1.46 %	Damping factor 1.32%

Figure 8. Modal analyses for the concrete slab without blanket.

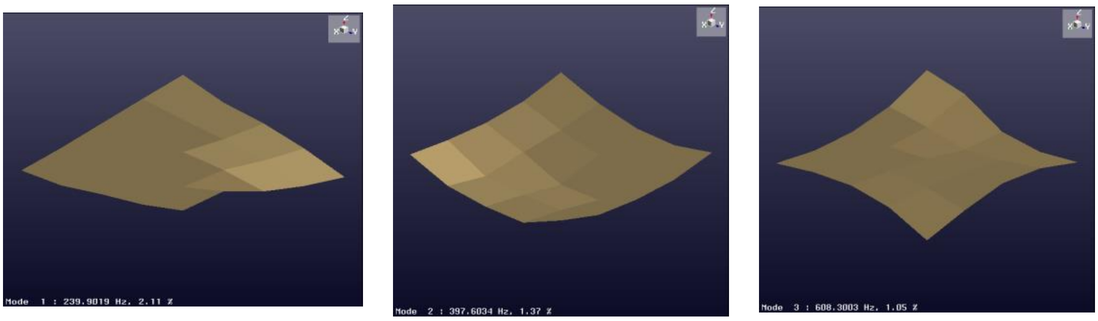
The analysis of the damping factor of the slab without the blanket, shown in Fig. 8, shows that there is a tendency to the decay of the damping factor with increasing of the vibration frequency, so the vibration levels increases and the tendency to increase the sound pressure is shown and confirmed by the previously evaluated sound pressure level tests.



Frequency 238.86 Hz	Frequency 399.35 Hz	Frequency 602.19 Hz
Damping factor 2.23%	Damping factor 1.44%	Damping factor 1.23%

Figure 9. Modal analyses for the concrete slab with commercial blankets.

Already with the use of 8 mm blanket of Company A, the results, shown in Fig. 9 shows that the damping factor at low frequencies is larger, the average frequency behavior is similar and the downward trend for high frequencies remains.



Frequency 239.9 Hz	Frequency 397.603 Hz	Frequency 608. 3 Hz
Damping factor 2.11%	Damping factor 1.37%	Damping factor 1.05%

Figure 10. Modal analyses for the concrete slab with mixture latex blanket.

Fig. 10 shows the results for the use of 5 mm thick blanket of latex in the medium and high frequency. Its behavior is extremely similar to the industrialized blanket, and the obtained differences is justified by the difference in thickness between samples.

4. CONCLUSION

Regarding the latex-based blankets that were analyzed in this study, the potential is clear and evident of these materials based on the results that were obtained from LnT'w, where all samples of this material, regardless of the composition, fit within the standards set by the NBR 15575, which provides a minimum performance for the building system in the range 66 to 80 dB.

It is noteworthy that the experiment has some limitations due to the characteristics of the scaled reverberant chamber. However, the validity of the research can be checked, because it proposes a testing methodology and demonstrate the potential of the tested material, which might be tested in a standardized manner, which can generate more innovative solutions in the future.

However, it is necessary to point out that it is still necessary to evaluate these samples in relation to other factors, such as fire resistance, etc.

Modal analysis and the results of the noise tests allow us to infer that the variation in the thickness of the blankets have influence directly on the isolation of the impact noise. However, since small variations in the samples were analyzed, it can be seen that for each 2 mm thick, a reduction of 4 dB in the frequency range 500 Hz is obtained. This fact is due to the damping provided to the system, due to the characteristic properties of the rubber that are evident in the modal analysis.

Regarding the type of analyzed additions that were mixed to latex, there were no major differences between samples, getting an indication of the blanket with addition of açai fiber for more detailed testing, because it gives the best sound pressure level reduction rates.

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