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ACOUSTIC EVALUATION OF A DENTISTRY CLINIC IN BELÉM-PARÁ

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Abstract. *The progress of some areas of human knowledge has brought innumerable developments and, in some cases, health risks for the humans, if a few things are not correctly observed. For the dentistry, the tools using during the treatment is one potential source of noise, may be a source of physical and psychological stress. This paper aims to acoustic evaluate and characterization of a dentistry clinic in Belém. The propose evaluation has been realized with the building analysis, identification of internal noise sources and measurements of this levels, and identification of the activities of dentists. The results has been compared with the NBR 10.152 standard, and then, did the tests of reverberation time and acoustic isolation to guide the development of corrective solutions to the problem. Therefore, it is estimated that the building do not have the parameters of acoustic comfort and some proposals for improvements that help in noise absorption within this enclosure.*

Keywords: *Acoustic, Noise, Dental Office, Acoustic Treatment, Acoustic Comfort.*

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

In modern society, human beings are exposed to numerous sound stimuli coming from daily routine activities of various orders. The response of these stimuli is subjective, so while a sound can be pleasant for some, it is considered uncomfortable by others. However, regardless of the subjective answer, the fact is that the human ear responds to sound intensity in the same way, that is, with effects that can range from discomfort to irreversible hearing loss. Almeira *et all* (2010)

Since the noise sound may be defined as the physiological response caused by a mechanical wave reaching the ear. Scientifically explained by acoustics as the sound sensation produced at the auditory system and consists of several sound waves concerning to amplitude and phase distributed anarchically, causing a connotative unpleasant feeling. (BISTAFA, 2011)

The odontologist is among the most affected by occupational noise, because the practice of the profession requires the use of noisy equipment. (TORRES, 2007)

Studies shows that healthcare professionals deserve special attention considering that the extra auditory effects of noise exposure, such as lack of concentration, can also cause serious accidents in attendance is necessary the real characterization of the professional and environmental exposure, and thus propose attenuation actions of noise effects.

This paper apply experimental methodologies combined with computational processing are, nowadays, one of the main tools of engineering for study and troubleshooting. A well-developed numerical model do not give up an experimental validation, and both methods together aid the understanding of the physical behavior involved and the same test solutions before construction. For computer simulation, we used the Odeon Software. This is a computational alternative to acoustic parameters calculations. It was developed by the Technical University of Denmark and is commercially distributed by Brüel & Kjaer. It works with an entry of a polygonal geometry that simulates the environment involved and the objects in it. The software processing is based on the geometric/statistics acoustics with hybrid algorithms of acoustic rays and source image. (B&K, 2015)

In additional it was compared the acoustic performance of the miriti fiber and the industrial processing board. The miriti fiber is extrated of buruti tree and The Buriti palm tree is especially important in the town of Abaetetuba (PA), which is 150 km from Belém, and is located in the Northeast of the State.

Various parts of the palm are used by the city community, the coconut is used in porridge and sweet;) the petiole (stem of the leaves) is used in handmade toys and baskets; the leaves are also used in crafts. Use miriti fiber as acoustic material is one of the focuses of work Vibrations Group and Acoustics UFPA and can thus contribute more concisely in the economy of communities and extractive cooperatives of the region through the sustainable management of the Buriti palm (SANTOS, 2010).

2. MATERIALS AND METHODS

2.1 Presentation of the study environment

The study target is a dental care clinic located in Belem, Brazil. Whose dimensions in meters are shown in the layout of Figure 1. The clinic is used for attendances about eight hours a day, is too small and consists of a sink, counters for organization of the materials, a chair for the patient and a chair for the professional . The room also has an air conditioner device, a glass door, painted brick walls and plaster ceiling. As shown in Figure 2.

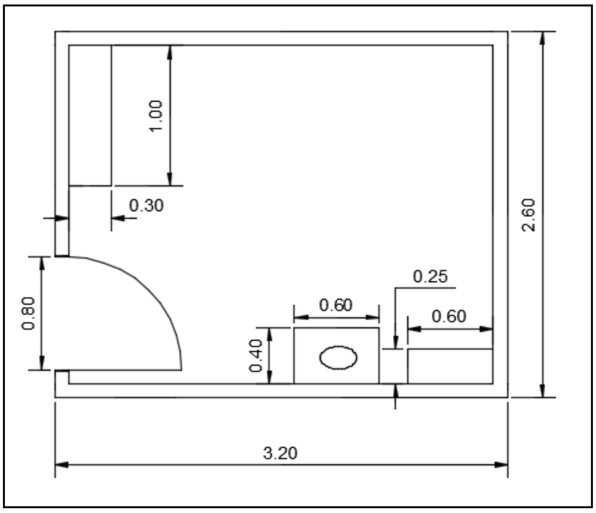

Figure 1. Diagram of shear modulus versus frequency at 303 K

Figure 2. Photo of the dentistry clinic for this paper.

2.2 Experimental measurements

2.2.1 Reverberation time

The reverberation time, TR, was measured according to the NBR 10151 recommendations for indoors. In the office involved, the measuring situation was with closed door, air conditioner on and the High Volume Evacuator off.

The NBR suggests the microphone positioning one meter away from any surface, one meter and twenty centimeters form the floor or ceiling and in three different positions, preferably half meters between them. The source is mounted one meter and a half away from the floor and half meter from any surface. An Investigator 2266 was used for this procedure (Figure 3 (A)), a diffuse-field 4189 microphone and a dodecahedral source model 4696, both from Brüel & Kjaer. Mounted as mentioned and shown in Figure 3 (B).

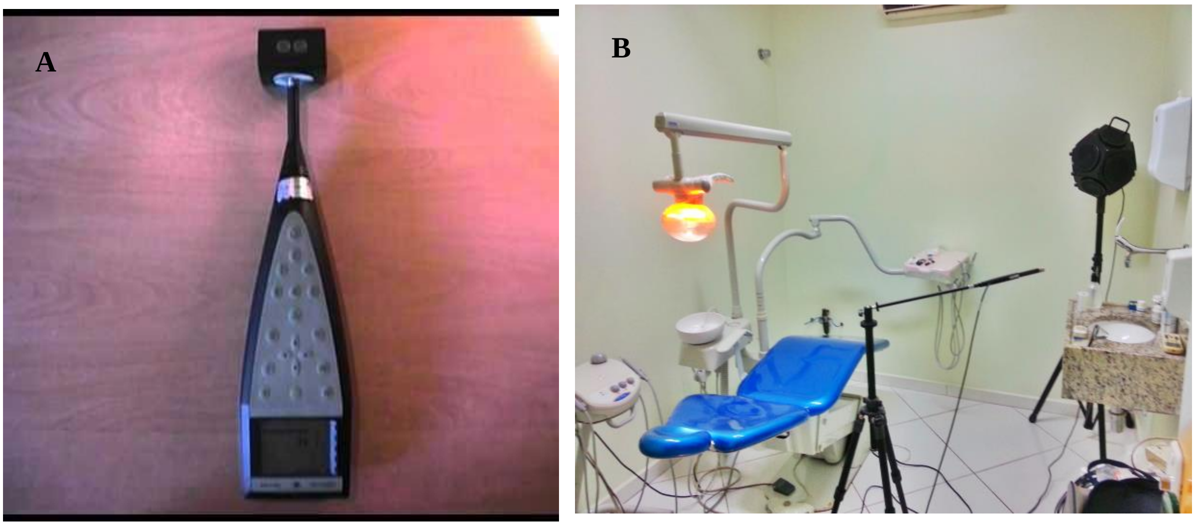

Figure 3. (A) Investigator 2266 with the microphone calibrator, and (B) Reverberation Time equipment's.

Due to reduced dimensions of the service area involved, measurements were made at three different points, with their duplicates for each point. Since, the Investigator at each measurement was set to display the value of the average of three acquisitions. Therefore, at the end, nine analyzes were made by point, ensuring the accuracy of the obtained data.

2.2.2 Sound Pressure Level

The sound pressure level, SPL was measured using the NBR 10151 recommendations for similar conditions to the reverberation time. First, measurements were performed for these conditions without activation of the dental turbine, characterizing the background noise environment. This analysis is required because of the proximity from a heavy traffic avenue, then the evaluation of the the impact of all these noises helps to have a concrete result.

Similar equipment were used, with the exception of the dodecahedral source. At this stage, four points were chosen for measurement, where for each point were made two measurements. The measurements took into account especially the two most used equipment, high and low speed dental turbines, thus, similar points were taken with only the high dental turbine on and then, only the low speed dental turbine on.

2.3 Computer simulation

The virtual model representing the surfaces present in the office was created using Google Sketch Up Make software, and exported to the Odeon 10 Industrial. The next step for the creation of the virtual model is the assignment of materials adopted in every surface. In this case, the model took into account typical materials from the Odeon library, presented in Table 1, and for the floor, a new material was created that combines the floor absorption characteristics and the chair together. The absorption coefficients were tested in order that the difference between the simulated and measured TR 30 were minimal.

Table 1. Material used in the simulation.

Frequency band		Absorption Coefficient							
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Surface	Material								
Ceiling	102	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Walls	102	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Sink	2001	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Counter	2001	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Door	10001	0.18	0.018	0.06	0.04	0.03	0.02	0.02	0.02
Floor	Custom	0.02	0.02	0.02	0.31	0.22	0.225	0.215	0.3
Absorption panel A	Custom	0.01	0.01	0.16	0.5	0.65	0.62	0.49	0.49
Absorption panel B	Custom	0.06	0.06	0.21	0.61	0.82	0.88	1	1
Absorption panel C	Custom	0.25	0.25	0.25	0.23	0.55	0.73	0.81	0.8

As shown in Tab. 1, surfaces were added on the walls and ceiling. Three types of panels were used in the calibrated model, all chosen for their polymeric coatings that ensure their easy cleaning and do not absorb microorganisms that invalidates the sanitary conditions of service.

Panels A and B are commercial, where the absorption coefficients are supplied by the manufacturers. The panel C is made of miriti fiber, used in the Amazon region for handicraft and it is highly common to find. The panel was manufactured to have a layer of PVC plastic that would allow its use in environments where cleanliness is required.

Then two sets of analysis were made when combining such materials, for both, the roof has been coated with material A. All the walls, with the exception of the one that contains the entrance door, were coated by the materials B and C, the exclusion of that is due to the fact that it has counters installed in the proximity of the point of care.

3. RESULTS

3.1 Reverberation time and calibration of the computational model

As the Schroeder Frequency was of 328.8 Hz order, the analysis stuck to the next frequency band. In possession of the experimental reverberation time, the computer model was calibrated with the materials presented, without the use of absorption panel. The results of the calibration are also shown in Figure 4 below.

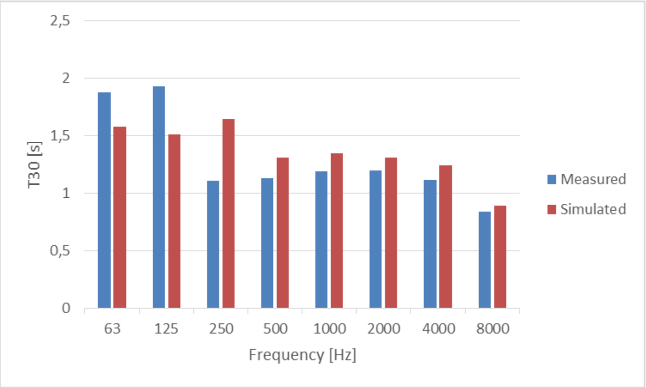

Figure 4. T30 calibration of measured and simulated values.

The mean difference between the computational model and the measured behavior, in the bands of interest, are in the order of 12%, which validates the model. It is also worth noting, that the higher the frequency analysis, the lower the difference achieved between experimental and simulated values. As in the studied case is expected the equipment to generate noise at high and medium frequencies, the computational model has proven effective in the simulation of absorption and sound phenomena involved.

3.2 Sound pressure level

In Fig. 5 the mean values for measured SPL are shown, by frequency band, for the high and low rotation dental turbines.

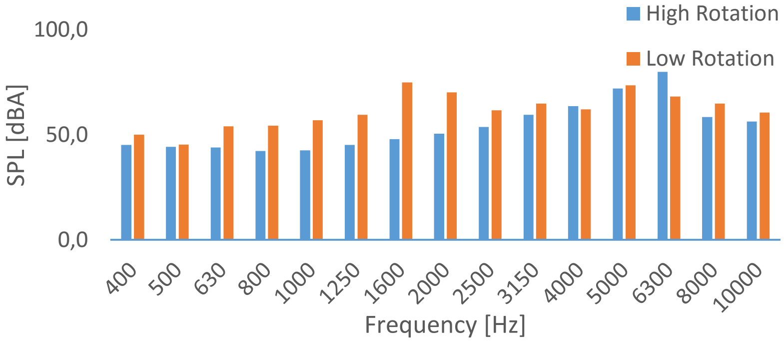

Figure 5. Measured SPL (A) values for the high and low rotation dental turbines.

The results show is consistent with the expected behavior by analyzing the rotation of the used equipment. It is also observed that the measured levels are above those allowed for hospital environments in the order of 20 dB in the presented peaks, then it is completely justified the acoustic treatment of the environment.

The analysis of Fig. 5 identifies not only the ambient noise criteria, but also the problematics frequency bands that elevate the sound pressure on the environment. In the studied case, the noise handling problems should be addressed at the medium and high frequencies. As the analysis adopted in the Odeon software is in octave band, the peaks at 4000 Hz for the high-speed dental turbine and 2000 Hz peaks for low speed dental turbines are worrying as noise source.

The chosen materials have to reduce these peaks as much as possible, decreasing the professional and patient exposure to stressful conditions.

From the experimental data, the Sound Power Level is calculated, SPL, by frequency band, thereby estimating what would be the power of the source capable to generate the measured SPL's. These values by band feeds the numerical model. It is then verified the accuracy thereof and the error between measured and simulated values for SPL. These results are shown in Figs. 6 and 7.

Figure 6. Calibration of SPL for the high rotation dental turbine.

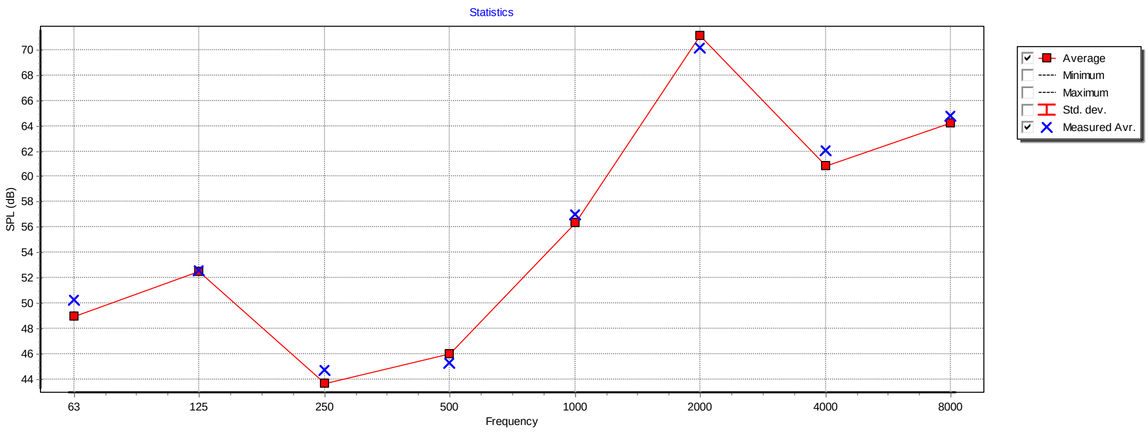

Figure 7. Calibration of SPL for the low rotation dental turbine.

3.3 Acoustic treatment proposals

With the calibrated computer model, in possession of the chosen materials, whose absorption coefficients are shown in Tab. 1, it was made the computer simulation to choose the best material for the acoustic treatment in that environment. In this case, the material should mitigate the sound pressure levels both for high rotation dental turbine as for low rotation. Fig. 8 shows the results for the first set of simulation, with the ceiling coated in material A and walls coated in material B, setting up a solution of commercially available industrial materials.

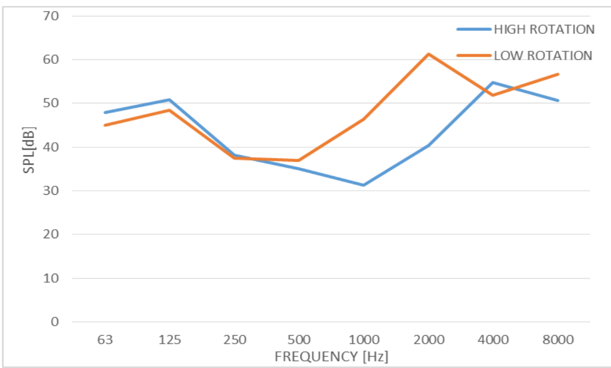

Figure 8. Computational answer for SPL (A) with the use on material A in the ceiling and material B in the wall.

The results shows an average reduction of 10 dB in the SPL where to the low rotation dental turbine, the peak of 2000 Hz is now with 61 dB and for the high rotation dental turbine, the peak is at 51 dB. For the studied materials, that was the optimal combination to minimize the sound pressure level in the environment without generating many costs.

The proximity of the simulated value for high rotation dental turbine with the standards set as comfortable validates the application of this technique for acoustic treatment.

In the second set of tests, the wall has been coated with panel C and the ceiling coated with panel A. Simulation results are shown in Fig. 9 below.

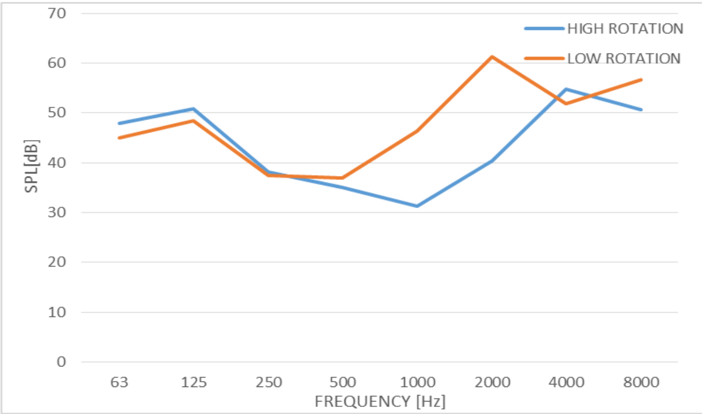

Figure 9. Computational answer for SPL (A) with the use of material A in the roof and material C in the wall.

It is noticeable a similar behavior with industrial materials, with a mean difference of 1 dB between the two simulated situations. It is also noticeable that the miriti fiber has such a good absorbent behavior as the industrial materials.

The analysis of the reverberation times of the room with and without treatment is shown in Fig. 10. It is perceptible the reduction of noise in the reverberation room and thereby the sound propagation by reverberation decreases.

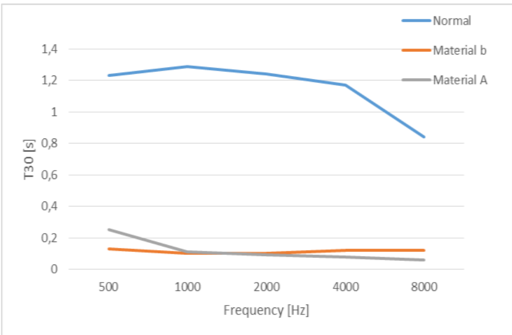

Figure 10. . Computational answer for T30 with the use of initial condition and after the acoustical treatment.

4. CONCLUSIONS

As an engineering problem, we tried to present an effective alternative that allies acceptable reduction, low cost and that guarantees hygiene and comfort to the professional and the patient. Two alternatives have been tested and both presented very similar values. As an alternative to the development of local communities, encouraging the production of Miriti panels proved entirely viable in the application of acoustic treatment, however, some more tests are needed, such as fire resistance. Anyway, the acoustic isolation capacity without compromising hygiene has been proven and if economic viability is real, this became an important alternative for the development of communities and societies local cooperatives.

As the achieved reduction, the peaks are found mostly in high frequency, then its reduction, even seemingly small, presents a significant improvement in quality of work and professional service. It is also noteworthy that the sound decay time in the room, the reverberation time, decreased enough, helping the sound to not propagate for a long time in the environment, improving comfort features.

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