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ACOUSTIC AND CINEMA: PROJECTION ROOM CASE STUDY FILM OF OLYMPIA CINEMA

Sarah Rassy Marques
Marcela Marçal Maciel Monteiro
Universidade da Amazônia, PA, Brasil
sarah.rassy@hotmail.com
arq3m@yahoo.com.br

André Vinícius da Costa Araujo
Universidade Federal do Pará, PA, Brasil
andrecosta@ufpa.br

Ivan Victor Corrêa Picanço
Universidade Federal do Pará, PA, Brasil
ivan.picanco94@gmail.com

Wagner de Sousa Santos
Universidade Federal de Santa Catarina, SC, Brasil
wagsousa16@gmail.com

Gerardo Alvez Nogueira Braga Neto
Universidade Federal do Pará, PA, Brasil
gerardo-ogueira@hotmail.com

Abstract. *Several factors affect the acoustic quality of an environment, and it is up to the designer to know how to control such factors, as depending on the type of environment and the activity to be performed in it, they require specific acoustical treatments. In places that need clear understanding of the word, such as a movie theater, for example, it is essential to control the reverberation time (TR), and isolation beatween internal and external noise. For the object of research, it selected a street movie theater in the city of Belém of Pará, the Olympia cinema, the oldest in operation in the country, being of extreme historical and cultural importance to the state capital. In this context, through experimental measurements and computer simulation with Odeon software, will assess the acoustic performance of the object of study room , based on the great TR found in NBR 12179/92, taking into consideration the enclosure volume , and a proposal for acoustic adaptation by indicating new materials that promote the best acoustic comfort of the environment, which in the case of this research, aims to reduce the room reverberation to meet the standard acoustic treatment enclosures closed.*

Keywords: *Acoustical treatments. Acoustic quality. Reverberation time.*

1. INTRODUCTION

In acoustic theater projects, the first concern to consider is the question of architectural acoustics. The exhibition halls should be designed for the best understanding of speech, meaning the viewer must clearly hear what is being said so that the project is not unsuccessful.

In Belém, there are some exhibition rooms that have problems related to acoustics, because the materials used in them end up preventing the entry of noise, especially external, in the environment. The city is characterized by having a hot and humid climate making it common to have rainy afternoons. Therefore, it is possible to hear the "noise" of rain inside theaters on rainy days, if the place does not have acoustic treatment. This certainly harms the experience and causes discomfort to the viewers.

In this context, considering the acoustic aspects indoors, the research covers the behavior of sound in exhibition spaces, focusing on the Olympia cinema screening room, located in the city of Belém do Pará.

For this, measurements of reverberation time and computational simulation were performed with Odeon Software.

The general objective of this research was to develop a study of the acoustic performance of the Cinema Olympia projection room, in order to evaluate the reverberation time, which is a feature that may impair the sound of the environment.

Specific objectives include: identify aspects of architectural acoustics that influence cinema projection rooms; study the behavior of different acoustic materials and propose those that are most suitable for the case study; perform experimental measurements of reverberation time, present in the environment according to ISO 3382-1 (Acoustics - Measurement of room acoustics parameters - Part 1: Performance spaces), and assess its suitability according to NBR - 12179 (Treatment soundproofing indoors).

2. BIBLIOGRAPHICAL REVIEW

The first projected cinemas that took acoustic studies into consideration were the works of architect Rino Levi. In these cinemas were studied acoustics, visibility, lighting (serving to highlight the facades), ventilation, audience flow, their importance in the urban landscape and construction techniques (Tamanini, 2011): "[...] Rino Levi's cinemas allow and require a deeper study of the project, highlighting elements, in this case the acoustics, which emphasizes his design reasoning and reveals the clarity of his architecture." (Tamanini, 2011, p. 30).

Architect Rino Levi, by developing specific projects for acoustic-focused movie theaters, made "his drawings less empirical and more technical, in addition to permanently deviate the projects of cinemas of theaters of theatres" (Lucchini Jr., 2015, p. 161). In addition, cinemas were built to shelter other uses on other floors (Lucchini Jr., 2015).

Acoustics have been used since ancient times with the Greek and Roman theaters, which, although giving priority to visual effects, the results obtained in these places are lessons that can not be forgotten. Already in the middle ages, acoustic functions were portrayed mainly in churches, because of the growth of Christianity (Souza et al., 2012).

Currently, acoustic concern is not only a matter of acoustic conditioning of the environment, but also of noise control and preservation of environmental quality. The issue of urban acoustics has become more important than before, as the number of noise-producing sources is increasing, and the consequences of these noises for man are increasingly harmful. (Souza et al., 2012).

Architectural acoustics involve defending against noise, meaning that all unwanted sounds must be eliminated, prevented from entering the room to avoid discomfort. It also involves sound control in the room, especially in places that need understanding of the word (cinemas, auditoriums, theaters) as there is a need for homogeneous distribution of sound throughout the room, preventing acoustic defects such as echoes and reverberations. excessive (Marco, 1986).

3. NORMATIVE AND NOISE LEVELS

The lower the noise levels, the better they allow for better quality in the workplace or at rest because overexposure to high intensity sounds causes psychological or physical health damage (Marco, 1986; Carvalho, 2010). Figure 1 shows indoor acoustic comfort levels established by NBR 10152, where the ideal values vary according to the activities that will be performed in the environment, but from 65 dB (A), it is already possible to perceive the discomfort. Depending on the individual to another, the values may vary, as the hearing sensitivity may be lower or higher for each human ear (Carvalho, 2010).

4. THEORETICAL FOUNDATION

4.1. Physical Properties Of Sound

Sound masking occurs when there is an overlap of sounds, that is, when several sounds strike at the same time in the same environment, being difficult to identify. In these situations, the sound with the highest intensity is the most noticeable, thus overlapping the sound with the lowest intensity. The diffraction of the sound happens when the sound wave encounters an obstacle (located between the sound source and the receiver) that has any tear and crosses it (figure 2), thus changing its direction and reducing its intensity (Carvalho, 2010).

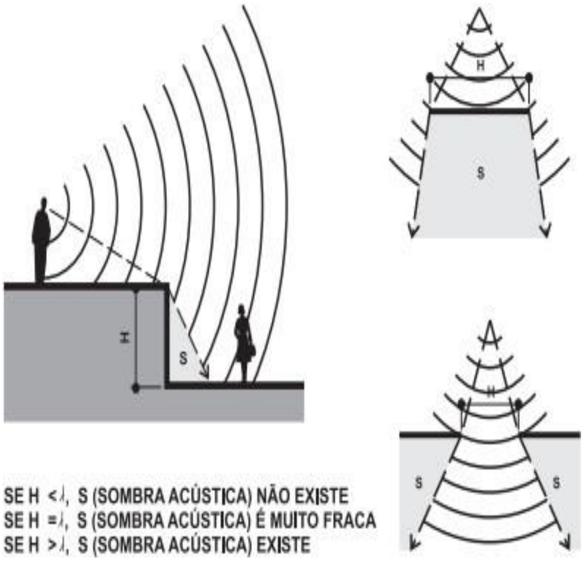


Figure 2. Sound diffraction
Available from: Carvalho (2010).

The refraction of sound occurs when the sound wave passes from one propagation medium to another, that is, a change of direction occurs. Another phenomenon is known as sound resonance, that is, the vibration of bodies that have the same frequency range (Carvalho, 2010).

Sound reflection occurs when sound waves hit a fixed obstacle and are reflected back to the medium in which it propagated. If the obstacle or surface is smooth, specular reflection occurs, ie the radius of incidence will reflect in the same direction and at the same angle. However, if it is rough, the reflection is diffuse, ie the waves will reflect at different angles (Marques, [2010]).

Sound reverberation is the prolongation of hearing sensation in a room. The longer the distance between source and reception, or the larger the volume of the room, the longer it will be. However, a little reverberation is always welcome, and the excess of it can be a problem, because it ends up taking the sharpness of speech (Carvalho, 2010).

Finally, there is still the phenomenon called echo, which occurs when the sound reflected on one or more surfaces returns to the receiver in a time interval greater than 1/15 of a second (Carvalho, 2010). The difference between echo and reverberation is in the time range of the reflected sound, when the time range is sufficient to distinguish the original sound. However, when this time interval is not sufficient, reverberation occurs (Marques, [2010]).

4.2. Acoustic treatment

For an environment to become acoustically comfortable, especially those that require the intelligibility of the word, there is a need for studies aimed at its acoustic treatment. The study should consider both the audibility conditions and the isolation from indoor and outdoor noise. Added to this, it is important to be aware of basic project-related elements such as: property rental; property situation; plants and cuts; permissible noise levels in the standard; the noise levels of the surroundings and the destination of the property (Carvalho, 2010).

In addition, it is necessary to acoustically condition the environment while giving better audibility conditions and acoustic comfort through TR corrections. Still, it is necessary to improve the distribution of reflected and absorbed sounds within the enclosure in the best possible way (Carvalho, 2010).

For a better understanding of the subject, concepts related to acoustic treatment, such as acoustic isolation, reverberation time and acoustic absorption will be addressed.

4.3. Acustic isolation

There are two types of insulation: airborne noise insulation and impact noise insulation. Isolation from airborne noise is related to airborne noise such as radio, television, etc. By focusing on a closure of the environment, sound waves cause vibrations that radiate energy to the other side (Marco, 1986). For this reason, the insulating materials for such a situation should be heavy and dense to obtain better acoustic insulation (Carvalho, 1967).

Thus, the amount of insulation that closure will produce will depend on the frequency of the sound that has been struck, as well as the constructive characteristics of the wall (Marco, 1986).

Insulation against impact noise is related to phenomena such as footsteps and knocking on the walls, the most important being floor impact. The amount of sound caused by such phenomena will depend on the construction of the floor and, especially, on the treatment of its surface (Marco, 1986).

Because of this, it is essential to act directly on the surface using soft materials on it that can absorb the impact such as carpets and rubber plates (Marco, 1986).

4.4. Reverberation time

Reverberation time (RT) is the range required for a sound to decay 60 dB after the sound source has been emitted, ie the sound that remains in the room after being emitted. For each environment, depending on the type of activity that will be performed inside, there is an optimal RT (figure 3), which can be calculated using the Sabine formula (Carvalho, 2010).

$$Rt = \frac{0{,}16\,V}{\sum(S.\alpha)} \tag{1}$$

Where V is the enclosure volume, S is the surface area and α is the sound absorption coefficient of the surface material.

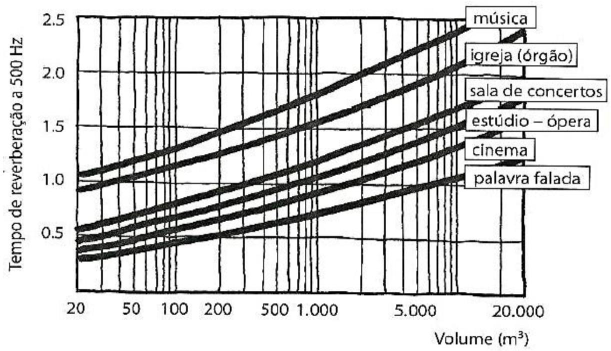


Figure 3. TR Examples for Different Room Types in the 500 Hz Range
Available from: Souza, Almeida and Bragança (2012)

If the reverberation time is too soon, sound overlap may occur, which compromises the intelligibility of the word. If the time is too short and the sound disappears soon after its emission, its perception will be compromised, especially at points farther from the source (Carvalho, 2010).

4.5. Sound absorption

Acoustic absorption is related to attenuation of sounds in environments so that they are not very reflected and thus decrease the reverberation inside the room. When surfaces are smooth and hard and sound hits them, much of it is reflected, but on soft or porous surfaces, much of the sound is absorbed (Carvalho, 2010).

The commonly used sound absorption coefficient is obtained experimentally in a reverberant chamber, and is called Sabine's sound absorption coefficient (Bistafa, 2011). Sound absorption, besides the coefficient, depends on the surface area. In an enclosure, the surfaces can be composed of different materials, each with different sound absorption coefficients, the average sound absorption coefficient can then be calculated.

4.6. Computer simulation

According to Cardoso (2010), the sound absorption coefficient is one of the main input data in commercial acoustic programs, such as Raynoise and Odeon. These programs have a library with sound absorption coefficient values for various materials, usually in octave bands. In Brazil, the standard ABNT NBR 12179: 1992 - Acoustic treatment of indoor enclosures, provides in its annex index values for various common materials and materials suitable for acoustic treatment. The Odeon software uses a hybrid model in its simulations, combining the image source method with ray tracing.

In the specular image source method, it is assumed that sound propagates as lightning, behaving as a flat wave and still considering attenuation due to spherical divergence.

Virtual specular image sources are used to trace the sound reflection paths from receiver R to source F, determining first order image sources. The energetic contribution of each image source is computed taking into account the distance traveled and the attenuations occurred in each reflection.

The ray tracing method assumes that the energy emitted by the sound source is equally distributed among a discrete number of rays, which, according to the algorithm, can be emitted deterministically or randomly. Each ray travels at the speed of sound and collides with surfaces and obstacles on which it is reflected according to the law of specular reflection. The energy level of each ray decreases with surface reflections and air absorption, when the ray energy level is no longer representative, the propagation of the ray is stopped.

5. METHODOLOGY

5.1. Procedures

For the development of the research, it was necessary to perform experimental measurements of the Reverberation Time inside the exhibition hall of Olympia Cinema. These evaluations happened on two days in October, both at the end of the morning and at the beginning of the afternoon, with the room empty and silent, that is, without a session and with the air conditioners turned off.

The first day of measurements took place between the hours of 12:00 and 14:00 hours. Already the second day of measurements was performed between the hours of 11:30 and 13:30 hours. The choice of different times for measurements was due to the availability of the cinema itself, according to its schedule.

The procedure for the measurements was based on the ISO 3382-1 standard of 2009. According to this standard, at least two sound source positions, 1.50 m from the floor, must be used for the measurement of the Reverberation Time. In addition, the sound sources should be positioned where the sounds from that environment might possibly be.

A minimum of six microphone positions were required at a height of 1.20 m from the floor with a distance of at least 2.00 m and should not be very close to the sound sources, ie with a distance of minimum of 1.50 m. In addition, such microphones should be placed in a position that the receiver would probably be and preferably distributed throughout the environment.

The RT measurement can be done through two methods: interrupted noise and integrated impulse response, with no differences in their values. Both methods require excitation of the environment, coming from their respective sound sources.

The interrupted noise method consists of pink noise emissions from a sound source, interrupted for a period of time, and the source abruptly switches off. Thus, the SPL (Sound Pressure Level) analyzer will average several sound decay curves, obtaining in the end a single sound energy decay curve, with which the reverberation time is determined (Tamanini and Bistafa, 2008). The sound source needs to produce very powerful noises and pressure levels that ensure a decay curve started at least 35 dB or 45 dB above background noise.

The impulse response method needs a pulse source, such as pistol shots, so that the environment can be excited. As with the previous method, the pulse source must produce a pressure level that ensures a decay curve starting at least 35 dB or 45 dB (depending on the parameter used - T20; T30 or T60) above background noise. For the present research, the interrupted noise method was chosen, with frequency ranges from 125 Hz to 4,000 Hz in octave bands.

As mentioned earlier, measurements were made in a quiet environment using the acoustic parameter T20, ie the time required for the sound pressure level to decay 20 dB after the sound was extinguished. For RT measurement, other parameters can be employed, such as T60 and T30, but the sound source power (used in the evaluation of the present research) was not sufficient to use them.

The sound source used produced a pressure level 35 dB above background noise, a value verified in the ISO standard for parameter T20 that was used in the measurements. With the results obtained experimentally, it is possible to make comparisons with the optimum RT (as a function of the volume of the environment) found in the norm NBR 12179/1992 (Indoor acoustic treatment) and, thus, to identify the good or poor acoustic performance of the exhibition hall.

However, this standard only offers values in the frequency range of 500 Hz, so even though the measurements have been performed in the other frequency ranges, already cited above, for comparison purposes (based on NBR 12179/1992), the only one that should to be used is the one of 500 Hz. However, it is also important to check the most deficient frequency bands, therefore, one can choose the ideal method for acoustic correction of the room.

In addition to experimental measurements, it is necessary to perform computer simulation to simulate different situations inside the room, especially with the room with people, since, experimentally, it was not possible to measure with the presence of public, a condition that can influence the results of RT.

In addition to experimental measurements, it is necessary to perform computer simulation to simulate different situations inside the room, especially with the same flood, since, experimentally, it was not possible to measure with the presence of audience, a condition that may influence the results of RT.

5.2. Equipments

For this type of measurement, the following materials were used:

- A 2260, Brüel and Kjaer sound pressure level analyzer with calibration certificate of 09/25/2014 or SPL analyzer;
- A calibrator type 4231, Brüel and Kjaer, calibration certificate 09/25/2014;
- A diffuse field type microphone, type 4189, Brüel & Kjaer, sensitivity 51.5 mV / Pa, 95% confidence level;
- A preamp type 2716, Brüel & Kjaer; and a dodecahedral fountain type 4296, Brüel & Kjaer.

5.3. Measuring Points

For the RT measurements of the Olympia cinema screening room, three positions were chosen for the sound source or dodecahedral source with a distance of two meters (figure 4). The microphones were positioned at eight different locations with a distance of 7.00 m.

According to ISO 3382-1, measurements should be made in such a way that the entire environment is studied and, for this reason, the choice of microphone positions was made for maximum distribution throughout the room. For better understanding, nomenclatures such as: F1, F2 and F3 for sound source; M1, M2, M3, M4, M5, M6, M7 and M8 for microphones, as shown in the figure. And, as described in the standard, the sound source and microphone were at a distance of 1.50 m and 1.20 m, respectively, from the floor.

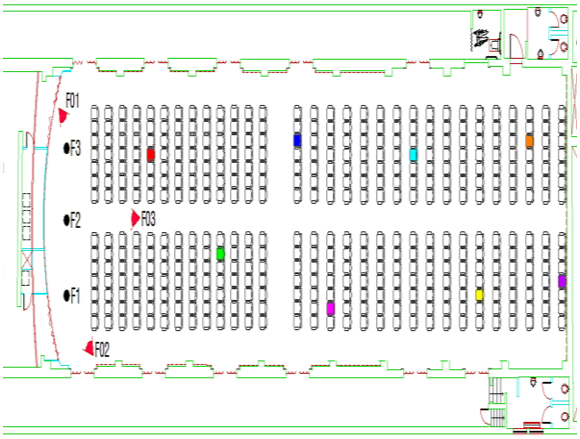


Figure 4. Measuring points
Avaliable from: authors (2015)

It is noteworthy that the source and microphone positioning points also take into account the configuration of the room chairs, trying to represent the position of the site users (figure 5).

Figure 5. Measurements being taken at cine Olympia
Available from: authors (2015)

6. RESULTS AND DISCUSSIONS

6.1. Reverberation Time Measurement

Reverberation time measurements were taken from 125 to 4000 Hz, obtaining results for each frequency band as shown in Table 2 for an example of microphone position (figure 6).

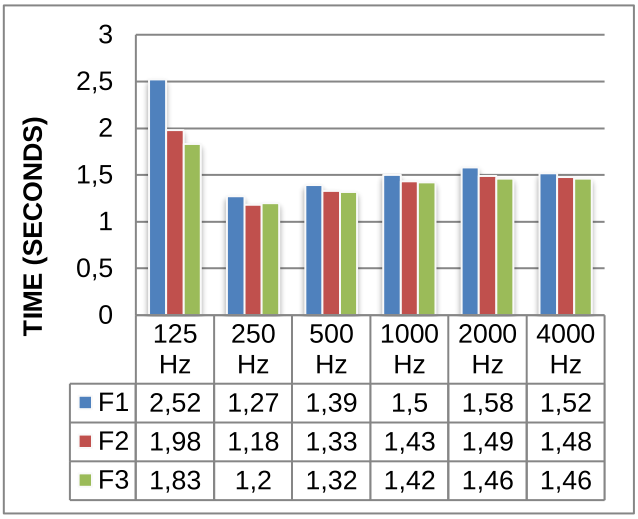


Figure 6. Reverberation time at nº 8 microphone position
Available from: Authors (2015)

Comparing all the measurement points, it was seen that the results at low frequencies were mostly little more than 1 second, but there were cases where the results were longer than 2 seconds or even 3 seconds. With this, it was noted that, especially from position M5, bass sounds become more difficult to understand or understand.

In addition, it was noted that the highest frequency bands (1,000 Hz; 2,000 Hz and 4,000 Hz) had the most similar results at all eight points, thus showing that the loudest sounds in the showroom Cinema Olympia are difficult to understand as they have had high results at all measurement times and at all three sound source positions. However, comparing the results for more bass and treble sounds, the treble sound ends up being more perceptive in relation to the bass, for the room under study.

Although the values mentioned above are calculated through arithmetic mean, it is possible to check, throughout the appendix of the work, the complete results obtained by the experimental measurements.

6.2. Optimum Reverb Time

Through the geometric data of the room and the properties of the room walls, it is possible to estimate the ideal reverberation time for the environment, thus being able to compare with the data obtained in the measurements. This procedure can be done according to the calculations demonstrated by Sabine or NBR 12179/92 - Acoustic treatment indoors.

NBR 12179/92 offers results only for the 500 Hz frequency band and, because the work already offers experimental measurements on site, only the volume calculations in m³ of the environment was required.

Despite several measurement repetitions, the room RT can be found by an arithmetic average of all points and in the frequency, range suggested by the standard. According to NBR 12179/92, the difference between the optimal TR established in the standard and the one found in the enclosure should be as small as possible.

When comparing the TR found in the room and the optimal TR present in NBR 12179/92, it was noted that the result was above the established by the norm for the 500 Hz frequency band, but the difference between both was only 0.33 seconds. The value is relatively good for a room built at a time when acoustics were not relevant or even unknown to its designers, despite several renovations.

6.3. Computational Model

To validate the experimental data, simulations were performed with the aid of Odeon software. The ODEON software aims to simulate and measure acoustics inside the enclosures, as well as in outdoor locations. ODEON uses the code imaging method combined with ray tracing. For the simulation in the program to be possible, it is first necessary to import the 3D model of the studied environment (see figure 7).

The software offers a variety of features for simulation, including a global library of surface materials in an environment, with their respective absorption coefficients. Given this, the materials present in the Olympia Cinema screening room should be researched.

However, there is not always the exact material on the list offered by the program or the material is not able to calibrate sufficiently because its coefficient is lower. In such cases, materials should be exchanged until the coefficients are satisfactory for program calibration against the measured results.

In the bill of materials, they are separated by groups, where all 1000 names are listed. In each category, the 100 raw materials should be referenced. If a library is not of material use, ODEON offers option for creation. A is a programmed bill of materials with its categories

After the model is calibrated, it is a useful result of many situations. Such results can be saved by the software itself and compared with the experimentally measured data in the same file.

Although there is a data processing logic, the process is no longer important when compared to the results obtained experimentally.

As mentioned earlier, the room model was built using CAD software and imported into the software program. For the case to have occurred, it was necessary to create a model for better reading by ODEON, as well as positioning the sound sources and microphones according to the experimental measurements.

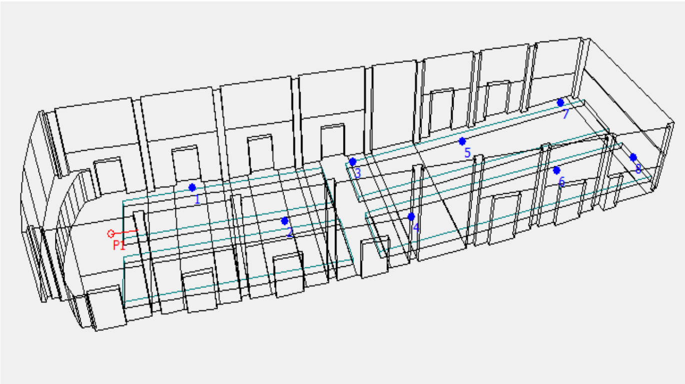


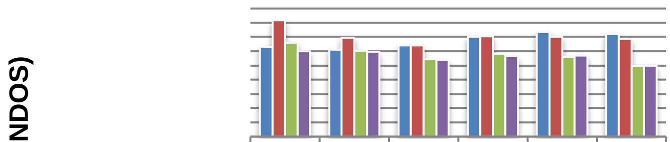
Figure 7. Computational model of cine Olympia
Available from: Authors (2015)

The absorption coefficients used for model calibration had to be searched and modified several times so that the simulated results could reach those obtained by the measurements. For this reason, not all materials used in the simulation exist in the enclosure itself, as the major importance is in the value of the coefficients (see table 1).

Table 1. Absorption coefficients used to calibrate the model in Odeon

Surface	Material (ODEON)	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Chairs	Leather Chair NBR 12179	0,13	0,13	0,1	0,07	0,05	0,05
Walls	Whitewashed plastered bick wall NBR	0,018	0,01	0,03	0,02	0,02	0,02
Stage	4mm abtestos or plywood board	0,55	0,3	0,1	0,05	0,05	0,05
Movie Screen	Movie ScreenNBR - modified	0,8	0,8	0,5	0,5	0,5	0,5

The simulation was performed in eight microphone positions and three sources, but for ease of understanding a general average of room reverberation times was made so that simulated and experimentally measured results could be compared. In ODEON software, it is possible to simulate various occupancy situations in a room. Considering this, the present work also simulated the half-occupied and crowded exhibition room, primarily without any treatment, ie, as it currently stands and with acoustic treatment, the latter being explained more clearly only in the next section. The higher the density of people, the shorter the Reverb Time, because the absorption is higher in a crowded audience. In the case of the simulation, although the half full room has a lower absorption coefficient than the crowded one, it was noted that there was not much difference between them, especially at high frequencies, unlike what occurred at low frequencies (125 Hz), where a large difference was observed (see figure 8).



	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Sala Vazia (Medido)	1,26	1,22	1,28	1,4	1,47	1,44
Sala Vazia (Simulado)	1,64	1,39	1,28	1,41	1,4	1,37
Sala 1/2 Cheia	1,32	1,21	1,09	1,16	1,12	0,99
Sala Lotada	1,2	1,19	1,08	1,13	1,14	1

Figure 8. Simulation results
Available from: Authors (2015)

Figure 9 illustrates the 3D model used to perform the simulation. Such models are offered by ODEON itself. The software recognizes only simple models and, for this reason, the chairs in the audience were made in a rectangular shape only to simulate the density of people in an audience. Figure 9. Room 3D model Available from: Authors (2015)

Figure 9. Room 3D model
Available from: Authors (2015)

6.4. Propose of acoustic adequacy

After the analysis made from the experimental measurements, it was noted that the cinema Olympia's screening room needs an acoustic adaptation so that the reverberation time of it fits the NBR 12178/92 - Acoustic treatment of indoor spaces. Being the RT of the room higher than expected by the norm.

For this to occur, it is necessary to change some materials that have higher coefficients, so that, consequently, there is a greater acoustic absorption inside the room and its TR decreases. Given this, this section will propose three options of acoustic suitability, compared to each other, in order to be chosen only the one that best fits the standard.

In the three options, the changes occurred only in the walls, because as they have a large area, the room TR has already decreased considerably just by modifying their materials by others with higher acoustic absorption coefficients. The proposals were also simulated by the ODEON Software, and in different occupancy situations such as: empty room; half full room and crowded room.

In proposal 01, the modifications occur in the sidewalls and the backwall, with the application of carpet and fabric throughout the surface. On the side walls, the carpet reached an average height of 3.50 m and then, to the ceiling, fabric was applied. On the back wall, the carpet reaches a height of approximately 1.20 m and, like the rest, with the rest of the fabric.

On the sidewalls, there are surfaces without the doorway, in which case fabric was used on the entire face. The carpet of choice is Beaulieu ASTRAL, with a weighted absorption coefficient of 0.15 to 0.20, and the thick draped curtain fabric with a coefficient of 0.45. The rest of the materials in the room were unchanged.

Figure 10. Propose 01
Available from: authors (2015)

Regarding acoustics, it was noted that the coefficients of the thick draped curtain were very high and, for this reason, the room TR decreased greatly compared to the norm in the 500 Hz frequency range. Very low TR also harms the sound of the environment, because the sound dissipates quickly, disappears into the room and is not able to be perceived or understood. The optimal TR found in the standard is 0.95 seconds (for the empty room), and with proposal 01, the site TR has fallen to

0.74 seconds for the empty room and 0.66 seconds for the half room. full and crowded.

In proposal 02, the side walls were also composed of carpet and fabric. On the back wall and surfaces without the doorway, only the carpet was used. In the case of this option, the fabric material was changed to light velvet, also pleated (even used on doors), because of its lower coefficient (with an average of 0.14), so that the TR does not decrease. very.

Concerning the acoustics, it was noted that the change of the curtain material by another one with a lower absorption coefficient caused the RT of the room to fall, but without harming the ambient sound. The optimal TR found in the standard is 0.95 seconds (for the empty room), and with proposal 02, it dropped to 0.98 seconds for the empty room; 0.88 seconds for the half full room and 0.89 seconds for the full room, values at 500 Hz.

In proposal 03, all walls, side and bottom, were composed of carpet. In the previous options, it was noted that the most responsible for the decay of the TR is the draped tissue, and for this reason, in this case, it was decided not to use it.

Regarding acoustics, proposal 03 was the one that obtained the best results and this was due to the removal of draped tissue. Although the carpet has lower absorption coefficient values (0.15 to 0.20) compared to other materials used in the previous proposals, ie fabric, the TR decreased considerably and this was possible due to the wall area of the room. Since the display size was large and with the low coefficients, it was possible to obtain values closer to the norm.

The optimal TR found in the norm is 0.95 seconds (for the empty room), and with proposal 03, it dropped to 0.93 seconds for the empty room; 0.85 seconds for the half full room and 0.84 seconds for the full room, room average values in the 500 Hz frequency range.

7. CONCLUSION

For a designer to perform acoustic projects, he needs to know not only the room and its activities to be performed, but also the concepts related to the theme, because it is possible to know the type of adaptation that a particular environment needs or will need.

In the case of a cinema projection room, the main factors that influence it are the reverberation time and noise control, because in a cinema it is necessary to understand and understand what is being said. When speech is not intelligible in this room or it is faulty, it is the responsibility of the designer to adjust the environment for the best comfort of its users.

In this context, the present research addressed the evolution of the exhibition halls and, thus, the evolution of the designers' thinking in relation to the architectural acoustics and its importance in this room typology. In addition, the key concepts related to acoustics and the appropriate materials for an acoustic project to be successful were explained.

The focus of the research is to study the acoustic performance of Cinema Olympia, considered the oldest still functioning cinema in Brazil, ie, being built at a time when there was no concern with acoustics, it was not designed to have complete speech clarity during displays.

Although, over the years, Olympia has undergone several renovations, it has been noted that, with regard to acoustics, the modifications made were still flawed, especially in the matter of room reverberation time.

With the results obtained, it was noted that the room would need acoustic adaptation projects. For this conclusion to be reached, a comparison of NBR 12179/92 - Acoustic treatment in indoor areas was made through an average of all results, as it was found as a function of room volume and in the 500 Hz frequency range. The room RT, measured experimentally, is

1.28 seconds while that found in the standard is 0.95 seconds.

The difference between the measured TR and the TR found in the norm was 0.33 seconds and, for this reason, it was thought of proposals to reduce the difference between the times.

However, such results were found for the empty room and, for the enrichment of the work, a computer simulation was performed with the ODEON Software in other situations of occupation of the room, ie half full room and crowded room.

For the simulation to happen, it was necessary to calibrate the program according to the measured results, and for that, a 3D model of the room was made, besides the choice of several absorption coefficients until the results were similar for the model to be validated. After calibration, it was possible to simulate the enclosure according to the proposed proposals.

In the beginning, the project was focused on choosing a material with the highest absorption coefficients, such as Isosound and Decorsound panels. However, the results obtained were much lower than expected and it was noted that a material with such a high coefficient was not necessary, but in the area in which it would be arranged, ie the wall.

The modifications could only be made on the wall, as it was noted that, as it had a large area, only modifying its material, the TR already decreased considerably. That is, the wall material was the most responsible for the above-expected result in the standard obtained during the experimental measurements.

In this context, three proposals for acoustic adequacy were chosen, each with its own material. For the first proposal it was suggested the placement of pleated thick curtain and carpet along the wall, but it was seen that the TR decreased a lot, with a result of 0.74 seconds, whereas in the norm the result is 0.95 seconds, that is, the difference between them was 0.21 seconds, which was detrimental to the room.

In the second proposal, carpet was also used, but the curtain fabric was changed to light velvet, because its coefficient is lower and, thus, the TR decreases, but not exaggeratedly. The result for this proposal was 0.98 seconds, just 0.03 seconds higher than expected in the standard.

For the third proposal, it was seen that the most responsible for the great fall of the TR was the pleated fabric and, for this reason, it was decided not to use it, that is, only the carpet was used. The result for this proposal was 0.93 seconds, just 0.02 seconds lower than expected in the standard.

Comparing the results of the three proposals, it was concluded that the only one that could not be used was the first proposal, while both of the following can be used. However, comparing proposals two and three, the latter was the one with the best result.

The Cinema Olympia, being a historic building, needed care at the time of designing the proposals, because it was necessary, through research in various documents, to know the types.

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9. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.