Multiplex cinema halls: Design and construction of six halls in the city of Mar del Plata

Roberto Daniel Ottobre\textsuperscript{(a)}, Marcelo Ottobre\textsuperscript{(b)}, Agustín Arias\textsuperscript{(c)}, Jerónimo Mariani\textsuperscript{(d)}, María Pérez Maraviglia\textsuperscript{(d)}, Oscar Cañadas\textsuperscript{(d)}

\textsuperscript{(a)} Ottobre & Ottobre, Asesores en Acústica, Argentina, arq.daniel@ottobreyottobre.com.ar
\textsuperscript{(b)} Ottobre & Ottobre, Asesores en Acústica, Argentina, arq.marcelo@ottobreyottobre.com.ar
\textsuperscript{(c)} Ottobre & Ottobre, Asesores en Acústica, Argentina, agustinarias@ottobreyottobre.com.ar
\textsuperscript{(d)} Estudio Mariani Perez Maraviglia, Argentina, estudio@marianiperezmaraviglia.com

Abstract

A shopping promenade that incorporates six cinema halls with capacities ranging from 150 to 310 locations has been built in the city of Mar del Plata, Argentina. The authors of this project were the architects Mariani, Pérez Maraviglia and Cañadas. The employer of the project was Florencio Aldrey Iglesias, who has a long and recognized trajectory both locally and nationally. The place chosen by the company was the former terminal bus station in the city, maintaining the main building, but reorganizing spaces and functions. In the docks area, a new building housing the shopping promenade has been built, with the six cinema halls on its top floor. The whole building complex alternates the respect for the tradition of the city, with the most innovative design. The indications given by the customer to the acoustic consultants were very clear, in the sense of providing an excellent acoustics quality, complemented by the latest technology equipment, including the new Atmos format of the Dolby Laboratories Inc. Starting from these premises, the following tasks were developed: a soundproofing project; a HVAC systems project with perfect accordance of the acoustic requirements, and an acoustic treatment project, developed using the AFMG’s EASE software. The project with its construction details, the model executed on software and the main measurements performed are presented.

Keywords: acoustic insulation, acoustic treatment, cinema
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1 Introduction

It is common to find cinema halls that do not meet the appropriate parameters for the screening of films. In Argentina this is verifiable in many multiplexes, from skimping materials and media during the construction works. The city of Mar del Plata is the headquarters of the Film festival that bears the name of the city, where productions from around the world are presented. In 2015, films were screened in the halls complex "Paseo Aldrey," as has been called the new promenade built in the city. It was therefore necessary to design the halls with appropriate technical framework, according to the importance of the event.

Moreover, in recent years there has been a paradigm shift in relation to the film format, because it has been left aside to work almost exclusively in digital systems. This meant a great simplification of production processes thus reducing the costs [1]. With regard to sound, that implies an increase in the dynamic range and a significant increase in transparency as intermediate compression processes disappear. Then, an environment that is in the most demanding point of the usual recommendations for this type of halls, both with regard to insulation and acoustic conditioning, is required. In addition, one of the halls must have the surround sound system Dolby ATMOS [2]. That was the task that must be developed, seeking to optimize the performance of building systems to get the best sound condition of the rooms in a framework of economic reasonability and short deadlines.

There were three premises with which it began: Reaching a 70 R\textsubscript{w} acoustic insulation between halls; get a noise profile NC 25, operating mainly on HVAC systems [3], and get a reverberation time as uniform as possible, around 0.5 seconds in the larger halls and about 0.4 seconds in the smaller ones [4] projecting a distribution of materials to help the intelligibility [5]. The acoustic project was generated from agreements with members of the study of Architecture and subsequent verification through simulation models, applying continuous monitoring on site, with measurements in situations of completion of each task.

2 The sound insulation

Previous experiments carried out by acoustic consultants and recommendations of Saint-Gobain were taken into account for the design of the sound insulation project. The halls have not only surface contact with each other, but also the two central halls (called 4 and 5) have contact with the engine room. Figure 1 shows a plan view of the cinemas.

One of the problems recognized in this type of halls is the mechanical transmission through the partitions, floors and ceilings due to low frequency sound energy generated in the reproduction of movies. The first guideline of insulation was to keep all joints with anti-vibration material and make a floating floor. This structure was raised over the existing slab as shown in Figure 2a.
Several kinds of vertical partitions were treated [6]. The most prominent corresponds to the division between halls, which was projected expecting a Sound Reduction Index $R_w$ of 70 dB value. These partitions typically incorporate an internal air chamber, which in this case should
be avoided by the need to meet the required width for the circulation areas. The partition used is presented in Figure 2b. This was designed from a structural profile for the support of all the facing, which at its highest point is nine meters high. The galvanized sheet structure holding the gypsum boards was mounted on these main profiles, using three on each side, the last being varied in stiffness and specific weight of the material. Inside the partition surrounding the metal columns which supports the complex, a glass wool filling with a total thickness of 200 mm was installed.

A similar configuration was used for the closing walls to the emergency exits and from the projection room, reducing the insulation to $R_w^{'} 55$ profile, removing thickness of the glass wool and reducing the amount of gypsum boards.

For ceilings, a casing composed of gypsum boards with a 100 mm thick glass wool above them was chosen, foreseeing $R_w 55$ dB insulation for each hall. The sound absorbing ceiling is supported from this set of materials, as shown in Figure 2c.

However, the most critical insulation was designed for the halls adjacent to the engine room, where a concrete block wall was built to increase the insulation. In this case, the noise levels of the equipment rise above 85 dBA, characterized as tonal noise with preponderance in the 250 Hz octave-band. In addition, the noise increases with the passage of time for various reasons, such as unbalance turbines or bearing wear. The wall was completed with the addition of "half linings" composed of gypsum boards on each side, expecting insulation higher of $R_w 70$, with a configuration as shown in Figure 2d.

### 3 The acoustic treatment of the cinema halls

Given the formal preferences of the designers, various coatings were selected in order to obtain both an optimum reverberation time and an appropriate sound field. Software models on E.A.S.E. (*Enhanced Acoustic Simulator for Engineers*) were performed, incorporating the geometry of the rooms and the materials chosen. Ceiling panels of rigid glass wool with black veil were installed on rooftops. These boards have 20 mm thickness and dimensions of 610 mm x 610 mm or 610 mm x 1210 mm. To avoid an excess degree of sound absorption at high frequencies, gypsum boards of 9.5 mm thickness and dimensions equal to the glass wool boards were added. They were placed in a checkerboard-style, i.e. not covering the entire ceiling, from the fourth row of the audience area to the back of the halls. Thus, a strongly absorbed first reflection surface was mounted, according to the recommendation for this type of halls. Figure 3-left shows the configuration used.

A layer of glass wool (supported on a metal grid) of 100 mm thickness and a density of 35 kg/m$^3$ was placed inside the air chamber behind the ceiling, at a distance of 20 cm. Thus, a low frequency trap was set up to provide absorption near the 80 Hz octave-band.

In the side walls, a membrane resonator was incorporated to solve the absorption at medium – low frequencies. It is composed of a plywood board from 6 to 8 mm thick. This material has a surface density of 4.5 kg/m$^2$ and was placed alternately on both sidewalls in modules. In addition, modules of 50 mm thick and 50 Kg/m$^3$ density glass wool were added on each wall, exposing to the interior of the halls their face covered with cotton fabric with flame retardant and
anti-acarus treatment. Then, modules compounds of the same cotton fabric were added in an interleaved with the resonators, leaving a rear air chamber of 10 cm. The combination of these three coatings is shown in Figure 3-right for Hall 3, being identical to the other ones. The rest of the surfaces exposed correspond to the insulation.

Figure 3: Left: Distribution of materials in ceiling. Right: Distribution of material on the walls.

3.1 Acoustic parameters

The following acoustic parameters were calculated for each room: reverberation time (Eyring and Schroeder); spatial coverage of sound pressure levels; speech intelligibility (%ALCons and STI); voice clarity (C50) index and frequency response. To perform these analyzes the software E.A.S.E. from the German company AFMG (Ahnert Feistel Media Group), version 4.3.9.75, license 73250-0284E-EA304-00000-EA4341, has been used.

3.2 Simulations results

The results for the Hall 3 are presented below. These results are similar and representative for the other halls. Figure 4-left shows the values for the Eyring reverberation time and, as can be appreciated, the results at medium frequencies are about 0.4 seconds, achieving values in each frequency band near to the recommended, represented by the lines of tolerance, with slight deviations at low frequencies. The exceeding values in the low and very low frequencies are corrected by the bass traps as explained in 3, although E.A.S.E. does not provide accuracy in that frequency range. These results indicate that the reverberation time of the hall is optimal.

To evaluate the other parameters, the chosen loudspeakers were installed in the simulation model, considering its directivity and real power. Loudspeakers of the brand QSC are used in all halls, precisely the "Stage SC-323" model for the L-C-R system and the "Sub SB-5218" model used as subwoofer.

Figure 4-right shows the results for the %ALCons parameter, used to quantify the degree of speech intelligibility. The values obtained are below 3% which classifies the intelligibility within the halls as "excellent".
Then, an evaluation of geometrical acoustics was performed on various listening positions (seats) located in such manner that a homogeneous spatial coverage is achieved inside of each hall. 700000 rays were emitted from each of the sound sources, a proportion of which reached the simulated listeners. The reflections were analyzed discretely with the addition of a statistical decay tail that allows obtaining others acoustic parameters of interest. Figure 5 shows the results on the seat 3 (row 11, at 2 meters of the central axis of the hall) for illustration purposes.

The distribution of reflections is homogeneous in all the reflectograms and there are no unwanted echoes or extreme colorations represented by late reflections with significant energy content above the reverberant tail.

The frequency responses calculated at each of the seats show that the spectral content is uniform over all the frequency range under analysis and there are no significant colorations. Figure 6 shows the results for seat 3
Then reverberation times were analyzed by the Schroeder's method to evaluate variations in different listening positions. Figure 7 shows there is a good correspondence between the two calculation methods, with some variations that suggest that the reverberation time turns out to be slightly higher than that obtained with the statistical method (Eyring), due to the addition of the statistical tail.

Several visits were made during the construction process, where the project's compliance was verified and some tests were performed. It was necessary to evaluate the acoustic insulation obtained through the relevant regulations. Furthermore, it was also necessary to verify the characteristics of the sound field obtained once the installation of the coatings was completed, including the background noise. For this purpose measurements were made using a sound level meter brand 01 dB Metravib model "Solo", connected to a computer with the dBBatti32 V5.2 software of the same company.
3.3 Insulation between halls

An evaluation of the sound insulation corresponding to the division masonry (wall) between the Hall 2 and Hall 3 was performed. The procedure was completed following the guidelines established in the Argentine standard IRAM 4063-4 (ISO 140-4) [7]. The apparent sound insulation index obtained is plotted in Figure 8, verifying the target value R’w 70 dB for the insulation between halls.

![In situ Measurement of sound insulation between rooms](image)

**Figure 8. Sound insulation index according to IRAM 4063-4.**

3.4 Background noise and reverberation time

During October 2015 measurements were carried out to determine the background noise profile obtained (with the HVAC systems running) and the final reverberation time of the hall. Figure 9 shows the state of the hall during these measurements.

With the air conditioning system in operation, the background noise levels obtained, in octave bands, correspond to those defined by the NC-25 profile established in the Argentine standard IRAM 4070 [8]. The hall meets the requirements in terms of the signal-to-noise ratio recommended for this type of activity (movies reproduction). It should be noted that this values correspond to the empty room. In the case of air conditioning system off, the results indicate that the room is adjusted to the NC-20 profile.
The background noise levels achieved for the empty hall demonstrates the fulfillment of an extensive list of recommendations generated by the acoustics consultants and a great work done by the executors in charge of the installation of the HVAC system. The main recommendations were: making ducts covered with glass wool; independent and separated equipment and branches for each hall; injection speed below 1 m/s; inserting an acoustic filter in feed and return ducts, so as to absorb the difference between the noise generated and that radiated in the first outlet; and finally the anti-vibration mount for all system components. However, and above all, the will of the employer, the project architects, installers and builders is highlighted for complying with all the requirements.

Figure 9. State of the Hall 3 during the measurements.

Inside the hall, eight points were chosen for the measurement of reverberation time. An average at each position and a global spatial average of the room were determined in order to avoid problems caused by local colorations or by local modes in the measurement points in each case. The recommendations of the Standard ISO 3382 "Measurement of the reverberation time in rooms" were followed [9]. Figure 10 shows the comparison between the spatial-averaged reverberation time with the projected values obtained from the simulations.

Figure 10. Reverberation times comparison. Spatial-average measured compared with projected values.
4 Conclusions

Acoustic insulation values measured in accordance with the regulations highlight the fact that the projected insulation between rooms, even without indoor air space and reduced in thickness, comfortably reaches the required index. The same applies to the background noise due to HVAC systems, a situation that is met with extreme difficulty in our environment and comfortably reached here. Finally, the evaluation of the reverberation time parameter shows that the objective has been achieved. Some considerations deserve to be taken into account regarding this case, as is the elevation of 0.1 seconds in the nearby of the 315 Hz third-octave band, which is associated with the resonances produced in the access to the room, below the level of the seats. Also the efficiency of the bass trap projected behind the ceiling, which extends his work below 60 Hz is highlighted.

Finally, it should be noted the awareness of the acoustic project that reached all the actors in the work: entrepreneurs, designers, directors, builders and installers.

References


