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Acoustics of the Border Cultural Centre in the neighbourhood of Palermo, city of Buenos Aires, Argentina

Roberto Daniel Ottobre\(^{(a)}\), Marcelo Ottobre\(^{(b)}\), Agustín Arias\(^{(c)}\), Guadalupe Cuello\(^{(d)}\)

\(^{(a)}\) Ottobre & Ottobre, Asesores en Acústica, Argentina, arq.daniel@ottobreyottobre.com.ar
\(^{(b)}\) Ottobre & Ottobre, Asesores en Acústica, Argentina, arq.marcelo@ottobreyottobre.com.ar
\(^{(c)}\) Ottobre & Ottobre, Asesores en Acústica, Argentina, agustinarias@ottobreyottobre.com.ar
\(^{(d)}\) Estudio Cuello, Argentina, mgarq@estudiocuello.com.ar

Abstract

The independent theatre, i.e. the one formed by groups of actors without the representation of an entrepreneur, has a long history in Buenos Aires. In addition to these cultural expressions, numerous musical groups and other disciplines are added to form a diverse and widespread artistic expression. A group of small halls is concentrated within the Palermo neighbourhood of Buenos Aires, designed to accommodate these artistic expressions. However, there was still no hall model located in a narrow terrain lot which allows performing simultaneous events, such as acting, music and dance, in the same building without interfering aurally with each other and fulfilling the noise regulations of the City. The projected room came to respond to that need. The architectural design of the cultural centre, which begins from spaces shaped by natural light, with large openings to the outside, was a challenge for the acoustic consultants. The acoustic project carried out for the theatre is presented, where the various solutions adopted to meet the acoustic requirements are shown, respecting and completing the decisive architectural concept.

Keywords: acoustic insulation, acoustic treatment, sustainable theatre
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1 Introduction

The Border Cultural Centre is a new art space located in the neighborhood of Palermo, consisting of a theatre, music and dance rooms, plus an art school and a gourmet space designed to create, represent and promote different artistic expressions in a conscious environment that invites to enjoy each experience as unique, impactful and meaningful.

The building concept envisaged several simultaneous activities, including amplified music and speech. The intended uses are:

- Bar: ambient music on both floors.
- Theatre: musical bands and theatre performances with or without amplification. The particularity of this space is that the sound must be able to run in the outside for the shows that take place in the garden.
- Music Room: music with or without amplification.
- Dance Room: practice and dance performances with amplified music and voice

Since activities can be developed simultaneously, it is necessary to ensure the sound insulation of the rooms so as to avoid interference of one over the other. Moreover, the reduced noise emission levels allowed outwards must be respected, according to the law of noise of the City of Buenos Aires. This neighborhood is characterized by noise conflicts between neighbors and owners of entertainment venues.

Figure 1: Sectional view of the building.
The building project took into account the natural light that reaches the interior, whose incidence is presented in figure 1 for the maximum and minimum of the solar declination, where the equinoxes are indicated in order to visualize the sunlight. Also airflow and its renewal were considered.

As can be seen in the section view of figure 1, the entrance hall is located on the ground floor. Behind the theatre stage, the ground floor courtyard is located, visual and functionally connected with the theatre room. On the first floor is located the foyer access to the main room, with a bar included. On the second floor are located the ballet and music room, linked through an open courtyard. Figures 2 to 4 show visuals of the various rooms.

Figure 2: Inside the Theatre.

Figure 3: Inside the Dance room.
2 The sound insulation

The Argentinian Standard IRAM 4044 [1] provides reference values for the sound insulation according to the type of activity. However, it does not indicate anything about the insulation characteristics of the partitions for the performance activity. So, it was necessary to resort to recognized literature for this type of events that provides guidelines on the matter. [2]

Table 1: Sound insulation. Recommended values.

<table>
<thead>
<tr>
<th>DIVISION TYPE</th>
<th>Sound Insulation $R_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dividing wall with neighbors</td>
<td>65</td>
</tr>
<tr>
<td>Horizontal partitions between rooms</td>
<td>65</td>
</tr>
<tr>
<td>Horizontal partition (terrace)</td>
<td>60</td>
</tr>
<tr>
<td>Walls or partitions of the rooms to urban spaces</td>
<td>55</td>
</tr>
<tr>
<td>Walls or partitions of the rooms to inwards</td>
<td>50</td>
</tr>
<tr>
<td>Windows to the outside</td>
<td>50</td>
</tr>
</tbody>
</table>

The values adopted for sound insulation, and its implementation, ensured that events could take place according to plan. This situation is verified since the theatre is in operation.

Furthermore, it was necessary to limit the background noise generated by the air conditioning systems. According to Annex A of the Standard IRAM 4070 [3], where the limit values of acceptable noise in unoccupied areas are detailed, the background noise spectrum should not exceed the spectrum of the NC profile considered for each type of room at any octave-band.
frequency. These profiles are listed in table 2. The final background noise levels should be checked with the air conditioner or fan operating at full capacity.

Table 2: NC profiles for each room.

<table>
<thead>
<tr>
<th>TYPE OF ROOM</th>
<th>PROFILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theatre</td>
<td>NC 20-25</td>
</tr>
<tr>
<td>Conference room</td>
<td>NC 25-30</td>
</tr>
<tr>
<td>Public Areas (circulations)</td>
<td>NC 35-40</td>
</tr>
</tbody>
</table>

In addition, the emission levels to the neighborhood that should not be exceeded were established in order to comply with the noise regulations of the City of Buenos Aires. [4][5]

2.1 Partitions and treatment of underground engine room

This insulation project consists in the formation of an inner box inside the engine room, separated from the mezzanine slab and the masonry. The purpose of this insulation is to minimize any perception in the major halls of the noise generated by the pump located within. This inner box in the ceiling and walls of the engine room consists of a cementitious board 10 mm thick, placed on a profile structure sheet BWG 24, of the type used for fixing gypsum boards, 70 mm wide. The interior space of the resulting chamber is filled with glass wool 70 mm thick and 35 Kg/m³ density. The ceiling of the room is suspended from anti-vibration mounts.

The entire surface of the walls and ceiling of the room is coated from 1 meter high with glass wool 50 mm thick and 35 Kg/m³ density, on which a perforated plate is arranged. The purpose of the placement of this plate is nothing but the mechanical protection of glass wool. Figure 4 shows the projected insulation.

Figure 4: Sound insulation. Machine room.
2.2 Partitions of the theatre

The walls showed in the figure 5 illustrate the insulation of the theatre. In this hall, two types of insulation have been used due to space requirements in the audience.

Figure 5-left illustrates the scheme chosen for the side walls of the stage, consisting of a type-C profile structure of 150 mm by 80 mm, with a lower wing of 10 mm and a thickness of 2 mm, installed on the dividing wall, which is completely revoked. On these profiles, two gypsum board 12.5 mm thick are placed, providing, inside the air chamber, a layer of glass wool 70 mm thick and 35 Kg/m³ density. This glass wool is held within the air chamber, resting on one of the surfaces or in the center of the chamber, and fixed with thin galvanized wires.

In the wall showed in figure 5-right, a structure for gypsum boards, made in caliber sheet BWG 24, with a nominal width of 54 mm was placed on the revoked dividing wall with three gypsum boards 12.5 mm thick. An acoustic barrier between the first two boards was provided. The interior of the air chamber was filled with glass wool 50 mm thick and 35 Kg/m³ density. This internal insulation structure, composed of three gypsum board, is 5 degrees tilted into the room from 1.20 meters high.

![Figure 5: Sound insulation. Theatre. Left: Stage wall. Right: Audience wall.](image)

Figure 6 shows the detail for the floating floor made above the theatre, in the corresponding dance room surface. This floor was executed with extreme caution so that there is no point of rigid contact between the floating slab and the partition walls, because, if so, the impact noises or the movement of any furniture on the floor is easily transmitted to the neighboring land. In the theatre, the termination ceiling was suspended below this structure.
2.3 Partitions of music and ballet rooms

The side walls of the ballet room have an identical insulation used for the sidewalls of the theatre stage, as can be seen in figure 7-left. For the remaining partitions, an insulation that continues the one used for the dividing walls was used with the addition of gypsum boards (resting on the dividing masonry), but this time on a structure designed for gypsum boards, made in BWG plate caliber 24 with a nominal width of 70 mm, on which two gypsum boards 12.5 mm thick were placed. The interior of the air chamber was filled with glass wool 70 mm thick and 35 Kg/m$^3$ density.

The partitions of the music room are illustrated in figure 7-right. They are composed of dry walls, consisting of C-type structure profiles of 100 mm by 60 mm, with a wing of 10 mm and thickness of 1.2 mm. On these profiles, two gypsum boards 12.5 mm thick were placed on one side and three gypsum boards 12.5 mm thick were placed on the other side. A layer of glass wool 70 mm thick and 35 Kg/m$^3$ density is located inside the air chamber.

2.4 Further considerations

Laminated and very thick glass windows and frames with double contact closures and sealed design were chosen. As for the doors, they are wooden with an estimated surface mass of 25 kg/m$^2$, using closures that ensure $R_w$ 42 dB insulation. Finally, the insulation for the noise generated by air conditioners on the terrace was ensured by installing acoustic screens for noise protection at the neighborhood.
3 Acoustic Treatment.

The reverberation time of each room was planned taking into account the various activities taking place. Table 3 shows the values opted, taking into account the recommendations of [6]

Table 3: Target reverberation times for each room.

<table>
<thead>
<tr>
<th>ROOM</th>
<th>R.T. (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theatre</td>
<td>1</td>
</tr>
<tr>
<td>Dance Room</td>
<td>0.6</td>
</tr>
<tr>
<td>Music Room</td>
<td>1.2</td>
</tr>
</tbody>
</table>

The theatre modeling was performed with the *E.A.S.E.* software, yielding a value of reverberation time for the room shown in figure 8 (with \( \frac{2}{3} \) of its capacity occupied). The necessary absorption was added in the ceiling of the room through perforated gypsum boards, behind which a layer of glass wool 70 mm thick and 50 kg/m\(^3\) density was placed. The same type of glass wool but coated fabric was added on the back wall of the room, near the access.

In the dance hall, the acoustic absorption is obtained by employing a tensioned and perforated PVC ceiling, behind which a layer of glass wool 50 mm thick and 50 kg/m\(^3\) density was placed.

For the music room, the decision was not to add any absorbing material, due to the size of the room and the insulation properties, obtaining the desired values without inconveniences.
Figure 8: Reverberation time calculated for the theatre.

Figure 9 shows the STI parameter, which is located at an average value of 0.61, complying with the grade of "Very Good" for intelligibility. [7]
4 Conclusions

The efforts made by the owners of this enterprise is worth mentioning in an economically difficult environment, since they not only started a building that responds to an advanced environmental requirements, but also agreed to carry out a major investment in sound insulation, more beyond the functional needs of the complex, caring for the environment noise pollution, which often causes numerous conflicts in the neighborhood.

References