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Office Acoustics: Problems and solutions.

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ABSTRACT

The spaces dedicated to administrative tasks represent a challenge from the acoustic point of view. In effect, companies instruct their architects about the characteristics that work spaces should have, such as ergonomics, lighting and spatial quality. There are rarely requirements for acoustic issues. The architectural, formal and functional proposals are generally opposed to the needs of good acoustics, encouraging the use of boundaries with neat and bright surfaces, which become true acoustic mirrors. Background noise is rarely analyzed, placing some limitation on the noise generated by HVAC systems. The isolation between rooms is limited to that achieved with the most elegant partition. In addition, the beloved and hated *open plan* offices sometimes concentrate hundreds of people who can talk at the same time, generating a true acoustic chaos. This article aims to internalize about the acoustic problems of the offices, taking reference companies that accurately guide their requirements and others that show some concern on the subject. Various technical solutions are presented, adapted to the formal requirements of the designers, with minimal investments, and with the objective of obtaining acoustically comfortable environments.

Keywords: Office, Architectural, Parameters.
I-INCE Classification of Subject Number: 51

1. INTRODUCTION.

The work of the acoustic consultant is sometimes ungrateful. It is common that the requirements come into conflict with the formal proposals of architects, who usually worry exclusively about design and functionality, and can hardly be convinced of the

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benefits of using techniques and materials that improve acoustic comfort if they do not fit exactly in the preconceived image. There are two concurrent issues in the peripheral countries: formally, acoustic materials are limited to a reduced repertoire in terms of design, colors and textures, and, from the legal point of view, there are no mandatory regulations on the need to evaluate the acoustic problem.

Therefore, the acoustic consultant can only make proposals within a very limited range of resources. The situation is different when the companies that install their offices are aware of the acoustic needs and have developed a series of acoustic requirements together with the corresponding lighting, ergonomics, etc. This article analyzes a real situation where, from a set of guidelines established for the parameters requested by the company, an optimum result was achieved in the formal, functional and, of course, in the acoustic.

2. CORPORATE OFFICES IN ARGENTINA.

2.1 Regulatory requirements

In the Argentine Republic, there are no mandatory compliance regulations related to the acoustic insulation and conditioning characteristics that must be implemented in offices. The IRAM Standards (which are usually translations or adaptations of the ISO Standards), are the only local references. IRAM 4070[1] is included here, which establishes background noise profiles due to the HVAC systems allowed for various activities. These profiles are referred to the NC Criteria (Noise Criterion Curves, a variation of the NR profiles defined in the ISO Norm) defined by L.L. Beranek in 1957[2] and widely used in America. In Annex A of this Argentine regulation, the maximum values shown in Table 1 are indicated for offices:

TABLE 1: Background noise profiles for IRAM 4070 offices.

Tipo de Local	Criterio NC recomendado
Executive Offices	NC 25-30
Private Offices	NC 30-35
General offices	NC 35-40
Large Offices	NC 40-45

The values proposed by the standard, with the exception of those corresponding to the executive offices, are simple to comply with, and can be achieved with minimal design precautions. The case of the executive offices usually requires, at least, to regulate downward the speed of the air and to use conduits that reduce noise, such as those covered with glass wool.

IRAM Standard 4044[3] establishes recommended minimum values for airborne and impact noise isolation for various activities, with an emphasis on housing, but does not establish applicable insulation values for offices. In the previous version of the standard, the isolation of homes and offices was comparable, but that situation is no longer verified in the new version. Therefore, since there is no reference in the local regulations for the isolation of offices, it is necessary to refer to other standards as well as in relation to the values of reverberation time. At this point the indications that companies give their designers can define a good or bad project from the acoustic point of view, by establishing a list of acoustic parameters that include all requirements, such as: isolation between partitions; background noise; Reverberation time; and compliance with any of the privacy indexes for open offices.

2.2 Requirements for a corporate building

The company Saint-Gobain of Argentina installed its offices in a building located in the Province of Buenos Aires, specifically in the city of Tigre. The interior project was carried out by the ESTUDIO ROSELLINI of Buenos Aires. The company presented a list of requirements that should be met, including acoustic issues. Table 2 shows a summary of these requirements:

TABLE 2: Values of acoustic parameters to be met.

Reference		**Descriptor**	**Unit**	**applicable to**	**Min Confort**	**Target High**
Acoustic comfort	AC1 - Sound level	Background noise : Equivalent sound pressure level (L_{Aeq})	dB	OO	<35	<30
				MR	<30	<25
				IO	<25	<20
		Peak noise : maximum sound pressure level (L_{AFmax})	dB	OO	<40	<35
				MR	<35	<30
				IO	<30	<25
	AC2 - Room acoustic	Reverberation time (Tr 500 Hz)	s		0,4<Tr<0,6	
		Intelligibility: Speech Transmission Index (STI)		OO	NA	NA
				MR/IO	>0,65	>0,8
OO: Open Office; MR: Meeting Office; IO: Individual Office.						

The isolation requirements were: 1) airborne noise DnT, w + C (dB) ≥ 45dB (min) and ≥ 48dB (optimum); 2) impact noise L'nT, w + CI (dB) ≤ 50dB (max) ≤ 45dB (optimum). It is possible to see that the levels of background noise (expressed here in L_{Aeq} values[4]) are much more demanding than those foreseen in local regulations. A maximum value is also established for the reverberation time at medium frequencies and for the STI parameter (speech transmission index). The requested insulation values are in accordance with the usual requirements for this type of space. This article presents the complete project of these offices, detailing all the parameters analyzed from the material test values made by the product manufacturers, and calculations made by the acoustic consultants.

The floors 5 ° 6 ° and 7 ° of the building were occupied with the same design that essentially repeats itself with small variations in each one of the floors. The perimeter of the building is completely glazed except for the stairwell and elevators, where there is also a small equipment room for the HVAC system. Each plant has an area of 500 m^2. The initial measurements allowed to verify that, with the plant empty, the noise level coming from outside was below the value of 35 dBA required, pending to evaluate the action of the HVAC systems in each space. In relation to noise impact, almost all areas have an elevated technical floor, which ensured compliance with the levels requested. Figure 1 shows an overview of the open office floor plan.

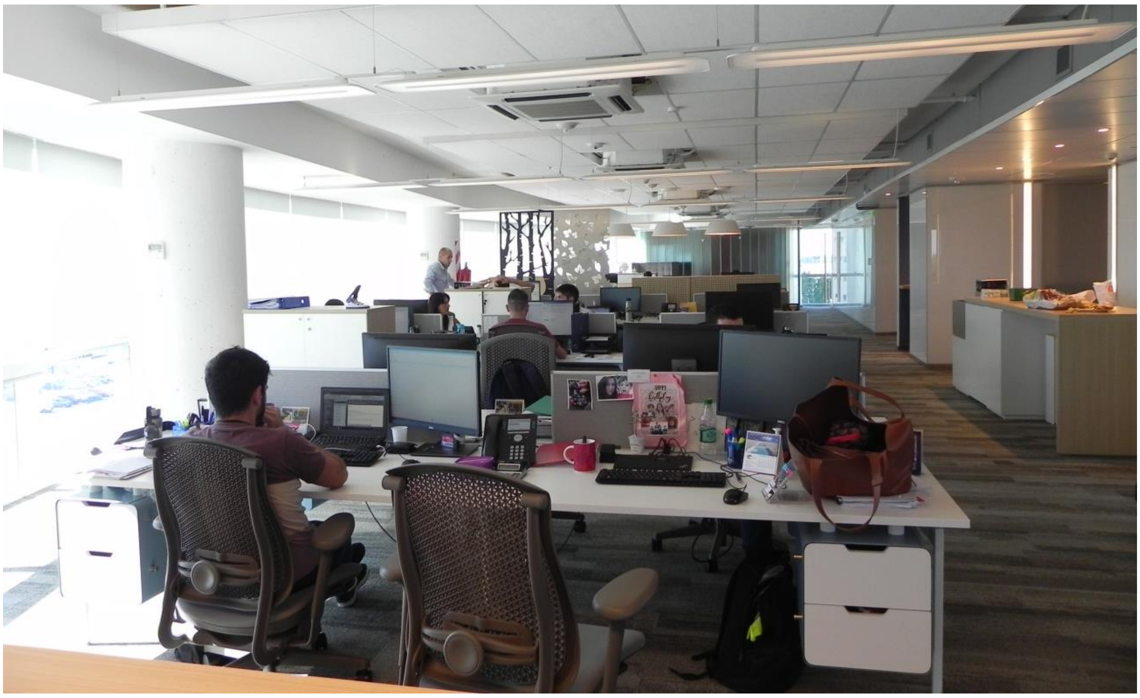
FIGURE 1: general view of the open office.

3. ACOUSTIC INSULATION

In the first place the type of partition to be used was chosen, opting for the greater isolation proposed by the owner. Starting from the basis that the construction would be carried out with dry systems, the available list of tests of local materials was analyzed[5] and it was decided to assemble a double gypsum wall plate filled with glass wool inside. This partition offers a R_w of 52 dB which would be met by excess with the requested insulation, although it is clear that the value of isolation in the laboratory cannot be achieved on site. The partition originally consists of four plates of gypsum rock of 12,5 mm thick, two on each side of a galvanized sheet structure of 70 mm thick, with glass wool Acustiver R filling. During the project, this proposal was modified, and a glass wool Acustiver P was added to guarantee the insulation. Finally, interior designers added an 8 mm thick glass to each side of the partition, to obtain the desired image and texture. Figure 2 shows a section of the partition and the ceilings.

The partitions were built “complete”, that is, covering the totality of the light between the mezzanines. The technical floors were placed afterwards. In some places, a gypsum rock ceiling was added to allow the passage of ducts and equipment, and a layer of glass wool was placed behind it to avoid resonances by improving the absorption of the resulting air chamber.

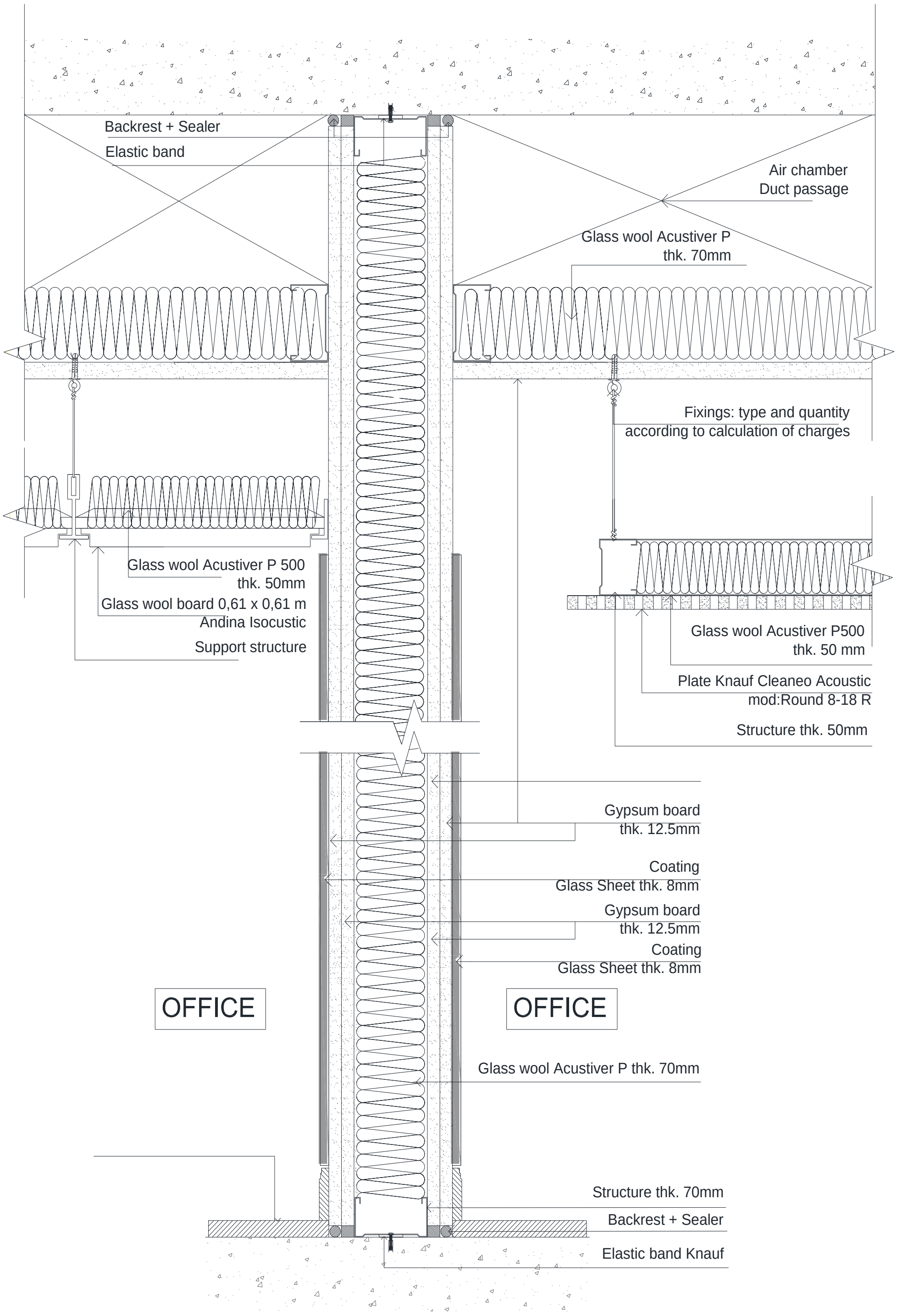

FIGURE 2: Section of partition and ceiling.

The glazed partition shown in Figure 3 was developed with a laminated glass of 8 mm, one of 6 mm and a PVB sheet of 0.76 mm (thicknesses). The crystals were mounted on stainless steel profiles, placed on sections of partition with the same characteristics as shown in Figure 2, to maintain uniform isolation. According to the information provided by the suppliers, this partition reaches an Rw 40 dB and, although it is under the required insulation, it is applied to a single office, located in the center of the plant, called “Board Office” or “Multimedia Room” on other floors. This proposal also resulted in a good technical-economic equation.

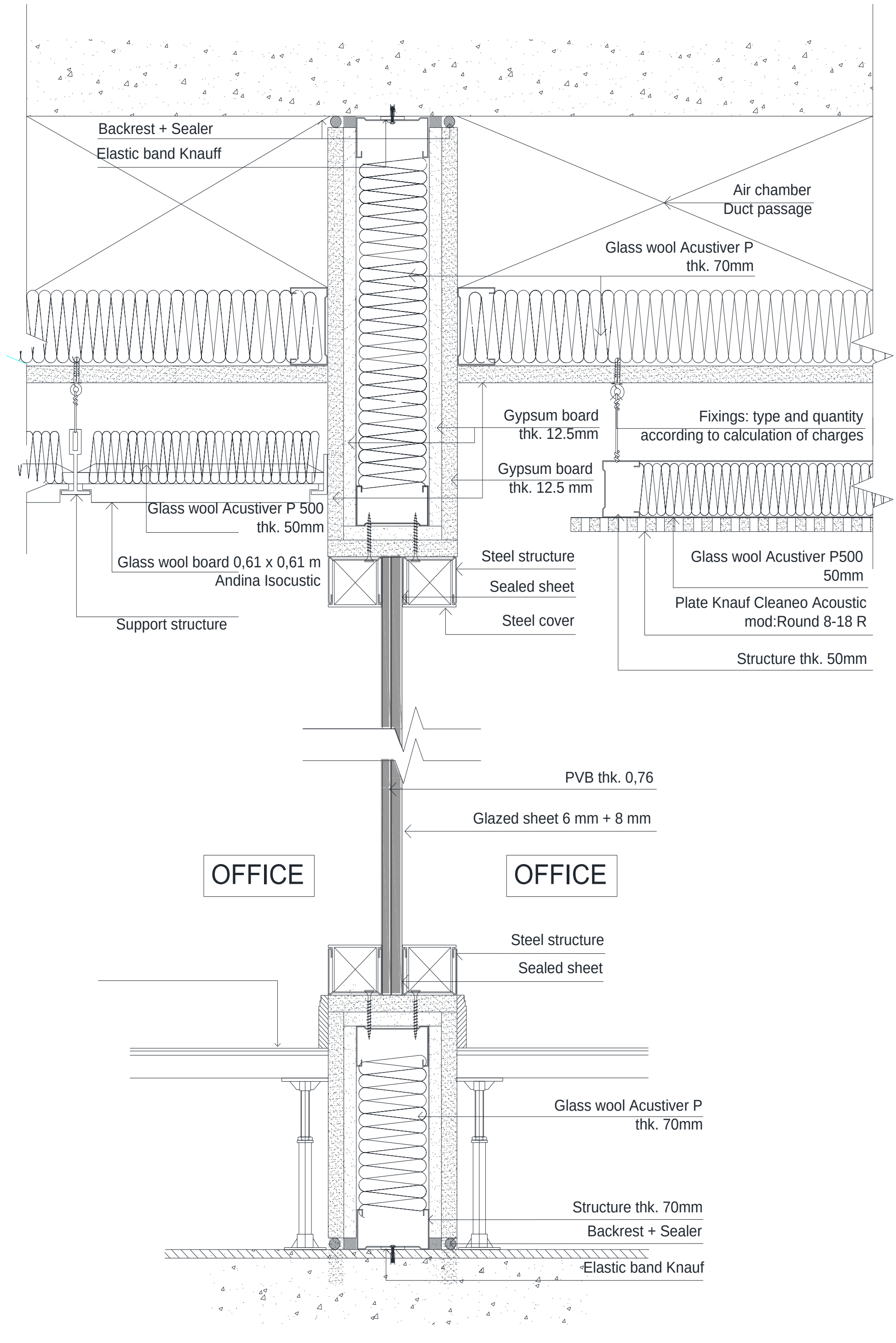

FIGURE 3: Glazed partition.

4. ACOUSTIC TREATMENT

The choice of sound-absorbing materials was evaluated together with interior designers, based on various proposals made by the acoustic consultants. The result was to use resonant perforated surfaces in the ceilings, which were presented in different textures and finishes with the same type of perforations, maintaining a similar aesthetic throughout the whole. Figure 4 shows the general distribution of the materials in the ceilings.

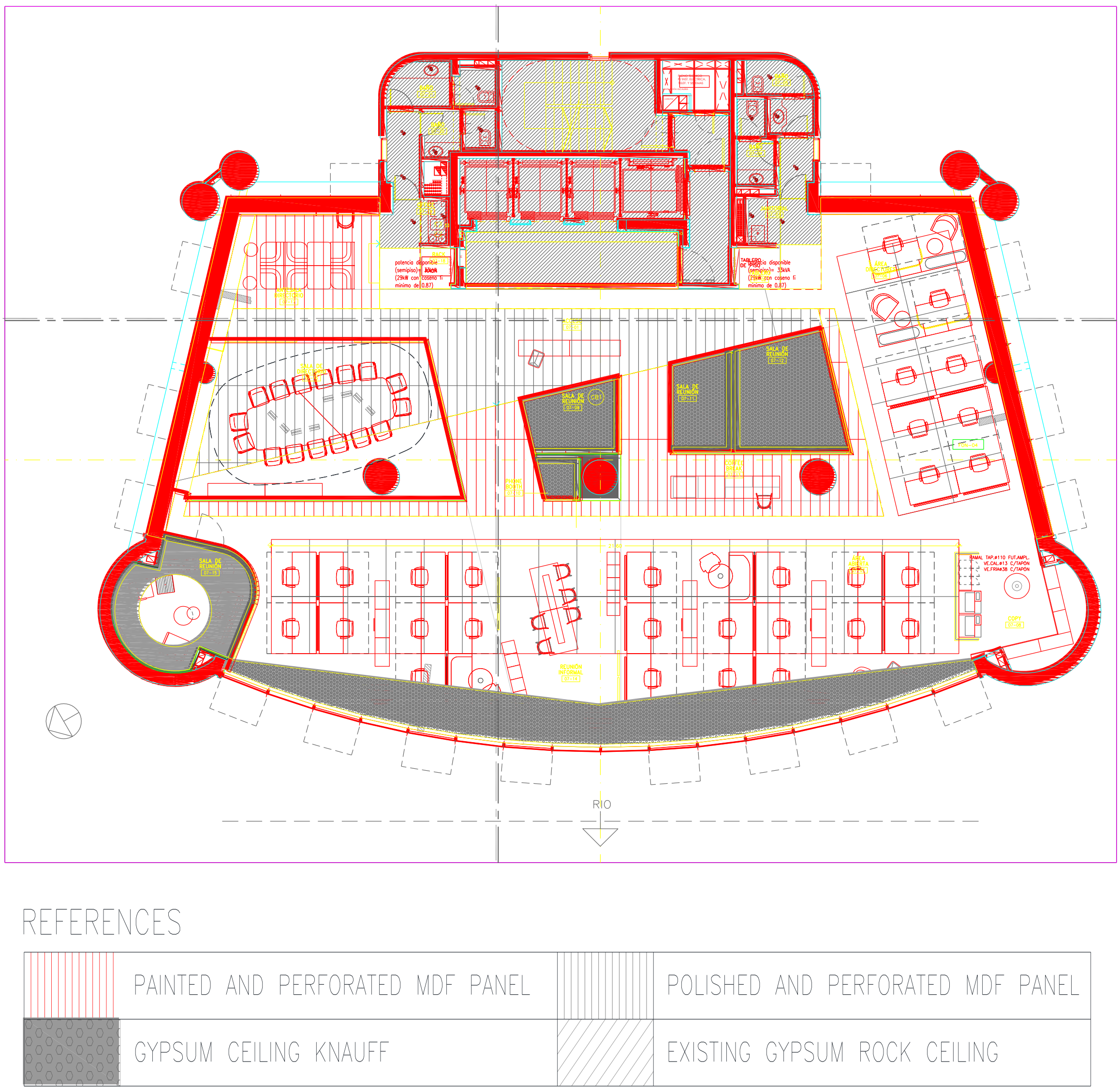

FIGURE 4: Typical floor plan and types of ceilings.

Figure 5 shows a view where the same type of ceiling, MDF (Medium Density Fiberboard) perforated, is presented in two terminations, with different textures and some small changes in the absorption coefficients. In all cases glass wool Acustiver P500 was used behind the materials, in order to widen the absorption bandwidth of the resonator. For the open office area, a 20 mm thick modular glass wool ceiling brand Isover model Andina Isocustic was used. In this sector, the ceiling was developed in “islands” separated of the lateral partitions, so as to expose to the environment both absorbent surfaces: the glass wool ceiling, and the glass wool, the latter covered with a glass veil. In the floors, a carpet was used covering the biggest surface, complemented with floating-type wood.

To calculate the reverberation time, the open floor was divided into smaller volume sectors due to the geometry of the space itself. The parameter evaluated was an average of the reverberation time at medium frequencies (500 – 1000 Hz) defined as RT_{MID}.

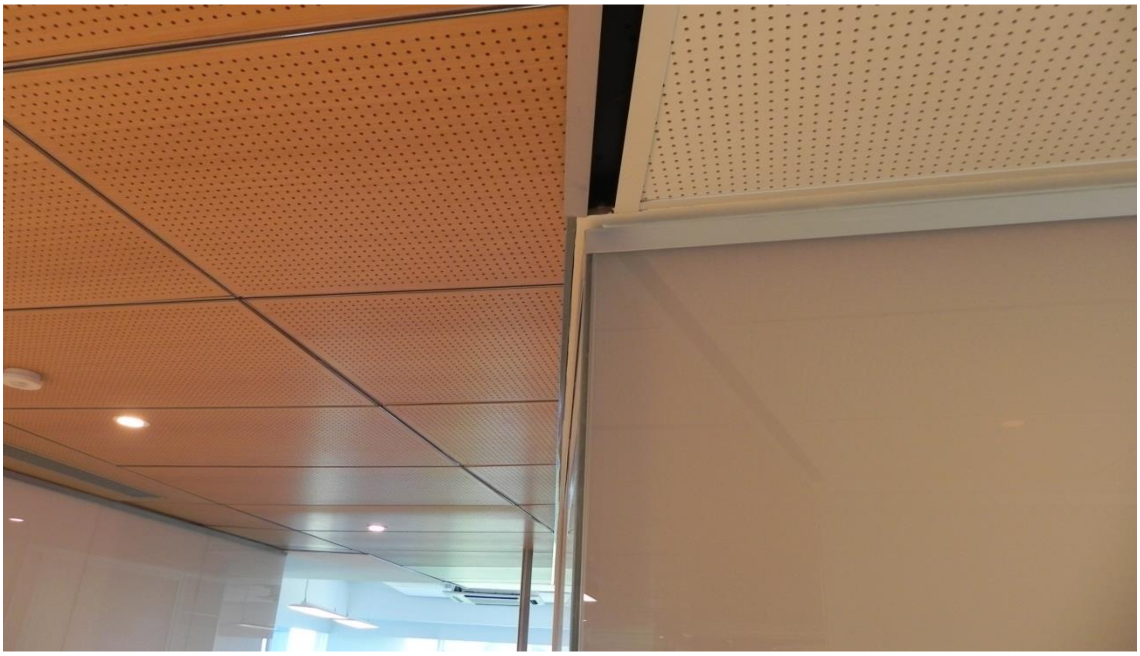

FIGURE 5: Image of two ceiling surfaces with similar perforation and different termination.

Tables 3 and 5 show the absorption coefficients of the materials used in the ceilings of the open office and the Board room, respectively. Figures 6 and 7 present a plan and perspective sketch of the surfaces of those spaces, while Tables 4 and 6 present a summary of the values of the Speech Transmission Index (STI) and the Reverberation Time at medium frequencies (RT_{MID}). The four "workplaces" used to evaluate the STI in the open office are illustrated in Figure 6.

TABLE 3: Sound absorbing materials of the open office ceiling.

OPEN OFFICE	**Sound Absorption Coefficients**							
	Octave Bands [Hz]							
Ceiling	**Area [m^2]**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Polished MDF panel (thick= 10 mm, open area= 24%, Ø=10mm, D=16mm) +25mm glass wool 50Kg/m^3	32	0,90	0,64	0,78	0,91	0,86	0,70	0,63
Painted MDF panel (thick= 10 mm, open area= 24%, Ø=10mm, D=16mm) +25mm glass wool 50Kg/m^3	47	0,88	0,64	0,78	0,92	0,88	0,75	0,69
Glass wool ceiling Isover Andina Isocustic 20mm	102	0,50	0,89	0,98	0,98	0,99	0,98	0,99
Gypsum ceiling Knauff Cleaneo Akustik 8/18 R	28	0,29	0,55	0,98	0,86	0,45	0,56	0,60

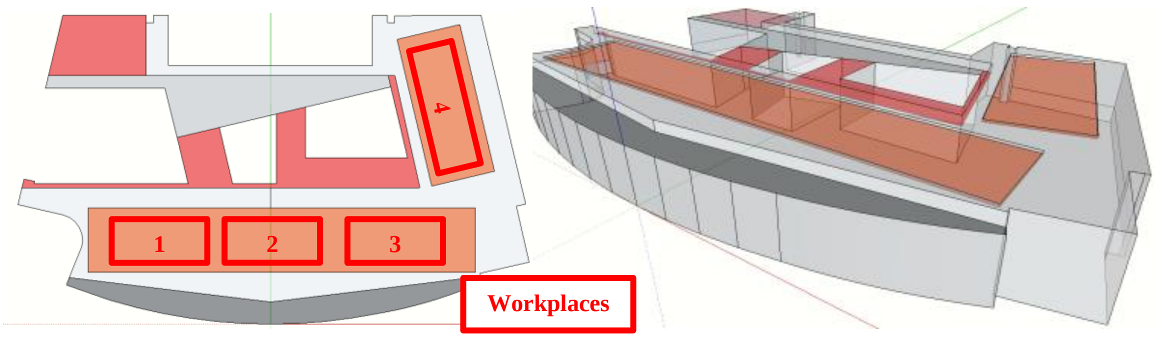

FIGURE 6: Floor (left) and perspective (right) with ceiling application in the open office.

TABLE 4: STI and RT_{MID}. Open office.

<table>
<tr><th colspan="6">OPEN PLAN OFFICE</th></tr>
<tr><th rowspan="2">STI</th><th>Workspace 1</th><th>Workspace 2</th><th>Workspace 3</th><th>Workspace 4</th><th>Spatial Average</th></tr>
<tr><th>Distribution [%]</th><th>Distribution [%]</th><th>Distribution [%]</th><th>Distribution [%]</th><th>Distribution [%]</th></tr>
<tr><td>0,76</td><td>0,0</td><td>0,0</td><td>0,0</td><td>0,0</td><td>0,0</td></tr>
<tr><td>0,78</td><td>0,0</td><td>0,0</td><td>0,0</td><td>0,0</td><td>0,0</td></tr>
<tr><td>0,8</td><td>0,0</td><td>0,0</td><td>0,0</td><td>0,0</td><td>0,0</td></tr>
<tr><td>0,82</td><td>0,0</td><td>0,0</td><td>0,0</td><td>0,0</td><td>0,0</td></tr>
<tr><td>0,84</td><td>3,9</td><td>0,0</td><td>2,6</td><td>18,3</td><td>6,2</td></tr>
<tr><td>0,86</td><td>19,7</td><td>11,1</td><td>18,3</td><td>17,1</td><td>16,5</td></tr>
<tr><td>0,88</td><td>15,9</td><td>15,9</td><td>14,4</td><td>11,9</td><td>14,5</td></tr>
<tr><td>0,9</td><td>14,7</td><td>15,6</td><td>11,3</td><td>9,3</td><td>12,7</td></tr>
<tr><td>0,92</td><td>12,3</td><td>14,4</td><td>13,5</td><td>10,7</td><td>12,7</td></tr>
<tr><td>0,94</td><td>8,9</td><td>11,5</td><td>10,1</td><td>7,9</td><td>9,6</td></tr>
<tr><td>0,96</td><td>7,5</td><td>9,9</td><td>7,9</td><td>7,1</td><td>8,1</td></tr>
<tr><td>0,98</td><td>7,0</td><td>9,1</td><td>8,7</td><td>6,9</td><td>7,9</td></tr>
<tr><td>1,00</td><td>10,3</td><td>12,5</td><td>13,2</td><td>10,7</td><td>11,7</td></tr>
<tr><th colspan="2" rowspan="2">Octave Band [Hz]</th><th colspan="2">Workspaces 1 - 2 - 3</th><th colspan="2">Workspace 4</th></tr>
<tr><th>T_{30} [s]</th><th>RT_{MID} [s]</th><th>T_{30} [s]</th><th>RT_{MID} [s]</th></tr>
<tr><td colspan="2">125</td><td>0,39</td><td rowspan="7">0,37</td><td>0,31</td><td rowspan="7">0,38</td></tr>
<tr><td colspan="2">250</td><td>0,49</td><td>0,42</td></tr>
<tr><td colspan="2">500</td><td>0,37</td><td>0,47</td></tr>
<tr><td colspan="2">1000</td><td>0,36</td><td>0,28</td></tr>
<tr><td colspan="2">2000</td><td>0,35</td><td>0,35</td></tr>
<tr><td colspan="2">4000</td><td>0,33</td><td>0,45</td></tr>
<tr><td colspan="2">8000</td><td>0,3</td><td>0,39</td></tr>
</table>

TABLE 5: Materiales fonoabsorbentes cielorraso sala de directorio.

<table>
<tr><th rowspan="2">BOARD MEETING OFFICE / MULTIMEDIA</th><th colspan="8">Sound Absorption Coefficients</th></tr>
<tr><th colspan="8">Octave Bands [Hz]</th></tr>
<tr><th>Ceiling</th><th>Area [m²]</th><th>125</th><th>250</th><th>500</th><th>1000</th><th>2000</th><th>4000</th><th>8000</th></tr>
<tr><td>Polished MDF panel (thick= 10 mm, open area= 24%, Ø=10mm, D=16mm) +25mm glass wool 50Kg/m³</td><td>26,13</td><td>0,90</td><td>0,64</td><td>0,78</td><td>0,91</td><td>0,86</td><td>0,70</td><td>0,63</td></tr>
</table>

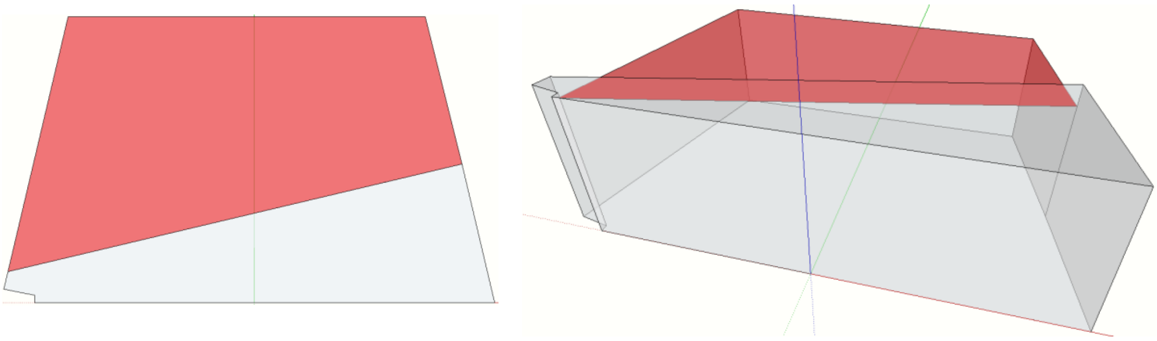

FIGURE 7: Floor (left) and perspective (right) with ceiling application in the Board meeting office / multimedia room.

TABLE 6: STI and RT_{MID}. Board meeting office / multimedia room.

<table>
<tr><th colspan="3">BOARD MEETING OFFICE / MULTIMEDIA ROOM</th></tr>
<tr><th>STI</th><th colspan="2">Distribution [%]</th></tr>
<tr><td>0,76</td><td colspan="2">0</td></tr>
<tr><td>0,78</td><td colspan="2">0,63</td></tr>
<tr><td>0,8</td><td colspan="2">70,8</td></tr>
<tr><td>0,82</td><td colspan="2">14,92</td></tr>
<tr><td>0,84</td><td colspan="2">5,46</td></tr>
<tr><td>0,86</td><td colspan="2">2,52</td></tr>
<tr><td>0,88</td><td colspan="2">1,89</td></tr>
<tr><td>0,9</td><td colspan="2">1,05</td></tr>
<tr><td>0,92</td><td colspan="2">1,05</td></tr>
<tr><td>0,94</td><td colspan="2">0,42</td></tr>
<tr><td>0,96</td><td colspan="2">0,42</td></tr>
<tr><td>0,98</td><td colspan="2">0,42</td></tr>
<tr><td>1,00</td><td colspan="2">0,42</td></tr>
<tr><th>Octave Band [Hz]</th><th>T_{30} [s]</th><th>T_{MID} [s]</th></tr>
<tr><td>125</td><td>0,27</td><td rowspan="7">0,37</td></tr>
<tr><td>250</td><td>0,49</td></tr>
<tr><td>500</td><td>0,39</td></tr>
<tr><td>1000</td><td>0,34</td></tr>
<tr><td>2000</td><td>0,37</td></tr>
<tr><td>4000</td><td>0,43</td></tr>
<tr><td>8000</td><td>0,39</td></tr>
</table>

As established in the table of requirements in Table 2, both the reverberation time and the STI are within the optimum values in each of the spaces analyzed. In this way the existence of a high degree of acoustic comfort is guaranteed. Figures 8 and 9 show views of the distribution of other materials used. Figure 10 shows a sector of the multimedia room with the glazed partition.

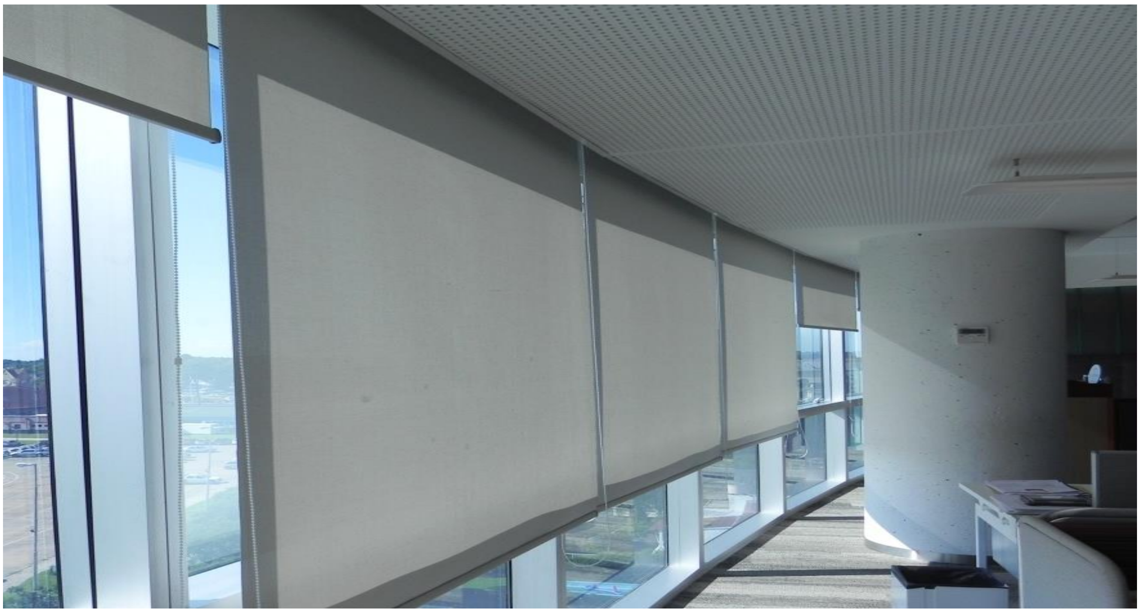

FIGURE 8: View of the perforated gypsum rock plate used.

FIGURE 9: Ceiling detail of glass wool plates on "islands".

FIGURE 10: Detail of the glazed partition of one of the multimedia rooms.

5. CONCLUSIONS

A corporate building was presented with acoustic requirements precisely defined by the owner, who was given an adequate response from the acoustic point of view, including a formal repertoire of materials with a formally clean, warm and pleasant image. From this perspective it was demonstrated that it is possible to create architecturally elegant spaces using standard acoustic materials. It remains to be clarified that the HVAC systems were intervened to generate low noise through the use of glass wool ducts and isolating the floor machine rooms. Although no measurements are available after the work stage, these were carried out by control companies, who did not need to contact the acoustic advisors since there is no need for changes.

6. REFERENCES

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