ACOUSTIC FALSE CEILING IN WIDE ROOMS, REALIZED BY AN INNOVATIVE TEXTILE SYSTEM

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ABSTRACT

The aim of this article is the study of wide rooms' acoustic false ceilings. In order to improve indoor acoustic comfort, it is possible to install an acoustic false ceiling. Many technical solutions are used to improve the inner room quality in terms of reverberation time and speech intelligibility. Restaurants and dining halls often can have acoustic problems caused by uncontrolled background disturbing noise. Indoor comfort can be seriously impaired in crowded rooms with many speakers, such as in restaurants and dining halls: the background noise produced by people talking damages the speech intelligibility level. If the speaker cannot be heard by his listener, he will speak louder. The speaker's increasing voice power will gradually intensify the background noise producing a domino effect (cocktail party effect).

In this case study we show the use of a brand new textile false ceiling system. This solution has just been installed in the Centre Hospitalier Universitaire Vaudois (Lausanne) new restaurant (1800 m^2) that can host 800 people. The innovative textile system, designed for this project, is composed of an aluminium structure within a shaped rock wool panel, enfolded by stretched EPS "acoustically transparent" fabric. This system, suspended from the ceiling and held by metallic lateral supports, improves the room acoustic quality, creating a nice dynamic effect as well. The installation of this system began in July 2014 and was completed in April 2015. We used the CATT-Acoustic software to analyse the room acoustic behaviour, the reverberation time and speech intelligibility.

Keywords: acoustic false ceiling, textile false ceiling systems, indoor acoustic comfort, speech intelligibility, reverberation time.

INTRODUCTION

Crowded rooms, such as restaurants and dining halls, often can have a low acoustic indoor quality. Disturbing noise produced in these rooms compromises customers' relaxing moment and the main room function. The acoustic issue of a workspace must be studied during project planning and design, in the same way as function and aesthetic tasks.

A comfortable environment gives to employees an optimum performance and makes them feel more predisposed to work. Workspace and relaxing places comfort is given by indoor environmental and acoustics quality. The interaction between the people, the room and the activity decides the room acoustic comfort, which contributes to the human well-being [1-3]. The room bigger and crowded the room, the more it could have acoustic problems: the size of the room and the number of the people inside threaten the indoor quality. One solution can be to install an acoustic false ceiling that absorbs the sound waves, reducing the reverberation in the room. There are many acoustic systems that can work as porous material or vibrant membrane; it depends on the material origin and the way that it is installed. The best system to choose is the one which absorbs the most, but , the solution's appeal is also important, especially in wide places [4-5].

In this research we want to study in deep the indoor acoustic comfort in wide rooms, based on a "case study", in which the indoor quality has been improved using an innovative textile system. In order to improve uncomfortable wide room acoustics, in terms of reverberation time and speech intelligibility, we can act on the ceiling, installing some kind of acoustic false ceiling.

CASE STUDY

In this case study we show a brand new textile false ceiling system. This solution has just been installed in the Centre Hospitalier Universitaire Vaudois (CHUV- Lausanne) new restaurant, see Figure 1. The project is part of a general renovation of the Centre Hospitalier Universitaire Vaudois, incorporated in a new local cantonal planning, called "PAC315", that includes eight big projects for the "Cité Hospitalière".

Figure 1: Google earth view of the CHUV (left); CHUV main entrance (centre); CHUV back side entrance (right).

The CHUV's Technical Direction's main purpose has been to give employers a comfortable relaxing place in terms of natural lighting and acoustic comfort. Natural light it is very important for human beings; the restaurant has three glass curtain walls that have a low indoor acoustic performance and low soundproofing. The 1800 m^2 (8100 m^3) restaurant can contain 800 people. The ceiling was the only surface that could be acted on, using a false ceiling system, with a good acoustic performance and pleasing appearance.

The Hospital Direction needed a false ceiling solution that could absorb as much as possible the sound waves. A traditional "plane" false ceiling placed in a wide and flat (around 4m) room can produce an oppressive feeling to customers. For these reasons the CHUV Main Direction called for tenders for the executive project and installation of an acoustic false ceiling solution. The project winning concept was to realize a well designed and dynamic structure, which would change its aspect on the restaurant width, length and height, in order to give customers a nice place to eat and relax.

The installation of the system began in July 2014 and was completed at the end of April 2015 (Figure 2).

Figure 2: Exterior view of CHUV installation (left); Indoor view at the end of the first step of the installation (right).

INNOVATIVE TEXTILE ACOUSTIC SYSTEM AND ITS APPLICATION

A very important parameter in the workplaces is the comfort, so it was important to project a system that could reduce the room reverberation time, considering the size and the crowding of the room. This innovative textile system (designed by Profil Tension System Europ Ltd and "Meier + associés architectes", Genève) is formed by an aluminum structure, called "sail", within shaped rock wool panel; everything is enfolded by a stretched EPS "acoustically transparent" fabric (Figure 3). These "sails" are suspended from the ceiling and held by metallic lateral supports. These structures have a different shape, in order to create a dynamic effect in the room and improve the room acoustic quality. Four "sail" types have been designed (Figure 4): the "V0", the "V30", the "V50" and the "V80". The number following the "V" means the angle degrees between the sail and the horizontal plan.

Figure 3: Sail prototype covered with fabric (left); Sail prototype without fabric (centre); photorealistic view of the restaurant (right).

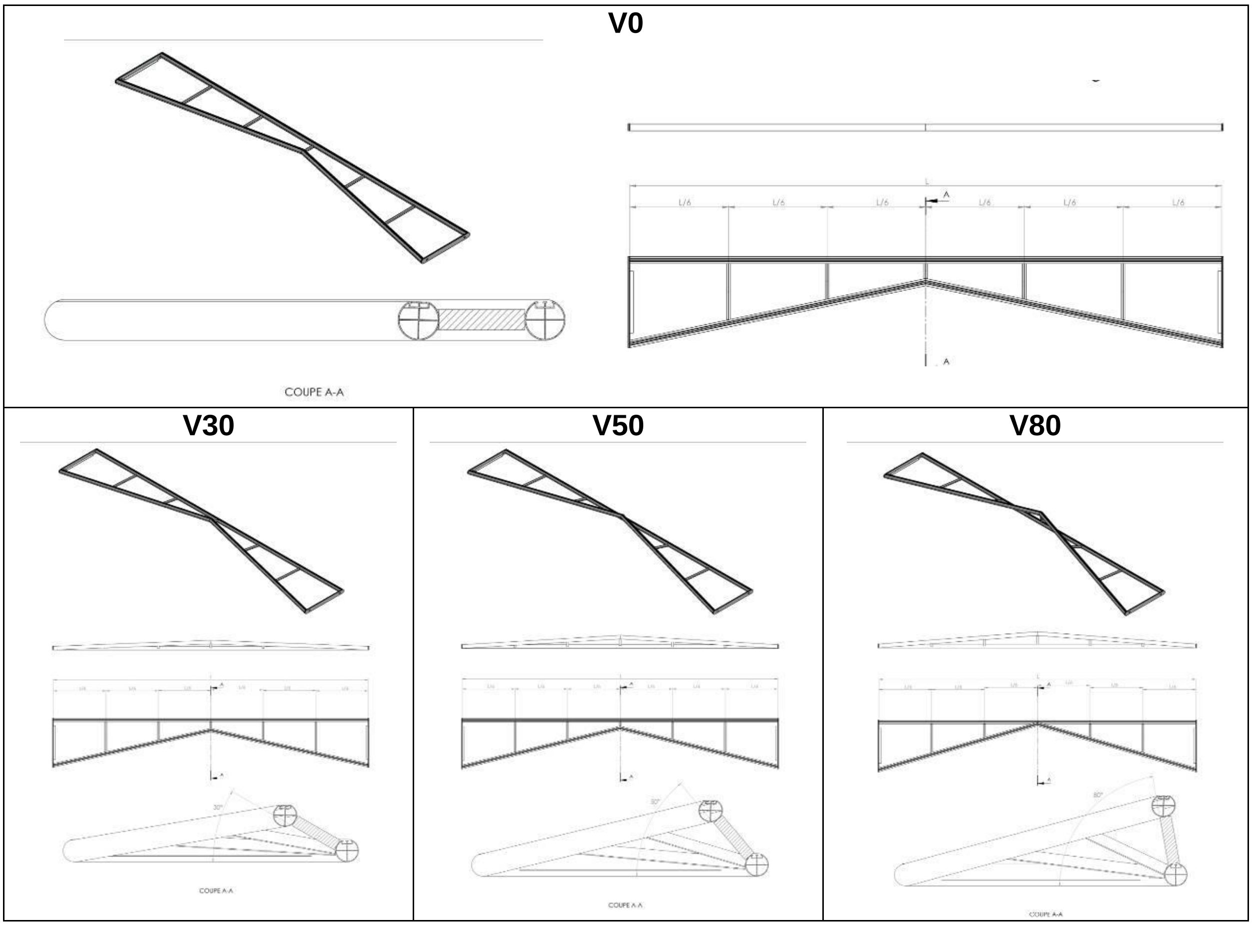

Figure 4: "V0"sail details (upper); "V30"sail details (down left); "V50"sail details (down centre); "V80"sail details (down right).

To fit the entire ceiling surface the "Sails" were designed with different lengths. The aluminum structure shape has an almost circular hollow section, to which are welded "T" profiles, necessary to hold rock wool panels. In the circular section there are two metallic stiffenings, which hold two PVC grips, called "Sollto Grip" (patented by Profil Tension System). These grips can induce tension in the fabric, giving the panel a uniform finishing (Figure 5). Rock wool soundproofing shaped panels (Figure 6) are fitted in the aluminum frame.

The "Sails" have a double exposed absorption surface giving a high acoustic performance (Figure 6). "Sails" are covered by an acoustically transparent fabric, extensible and can model itself on the shaped panel, hiding what is inside.

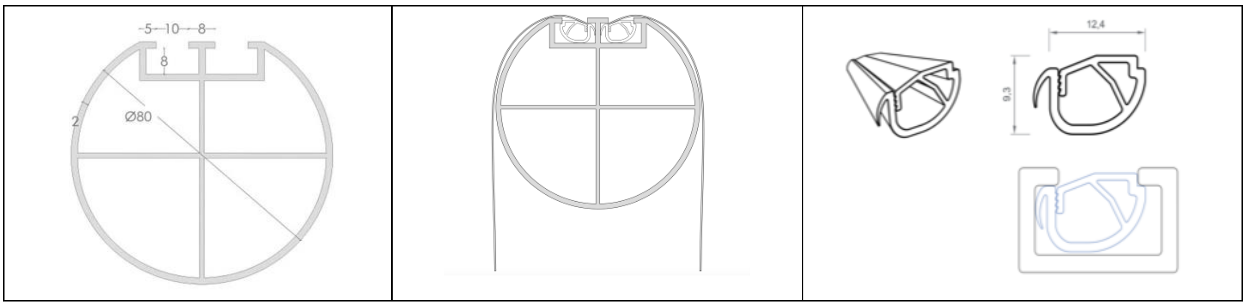

Figure5: Details of the aluminium structure and "Sollto Grip".

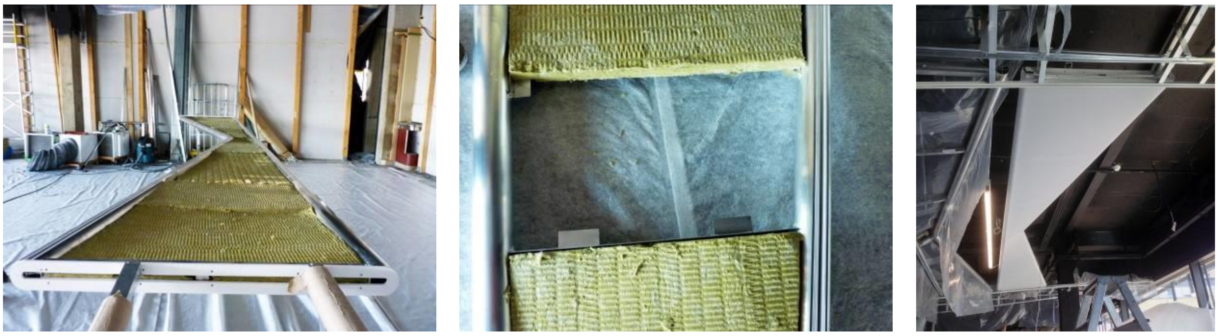

Figure 6: Views of the shaped rock wool panels (left and centre); sail covered with EPS fabric (right).

The false ceiling system is made of 237 “sails”, different in dimension and type, suspended by lateral metallic rails, connected to the structural columns. The dynamic effect was created putting the less sloping ones in the restaurant perimeter and the most sloping ones in the middle. There were installed: 85 elements type “V0”, 40 type “V30”, 52 type “V50” and 60 type “V80” (Figure 7). This project was integrated with lighting and air emission systems.

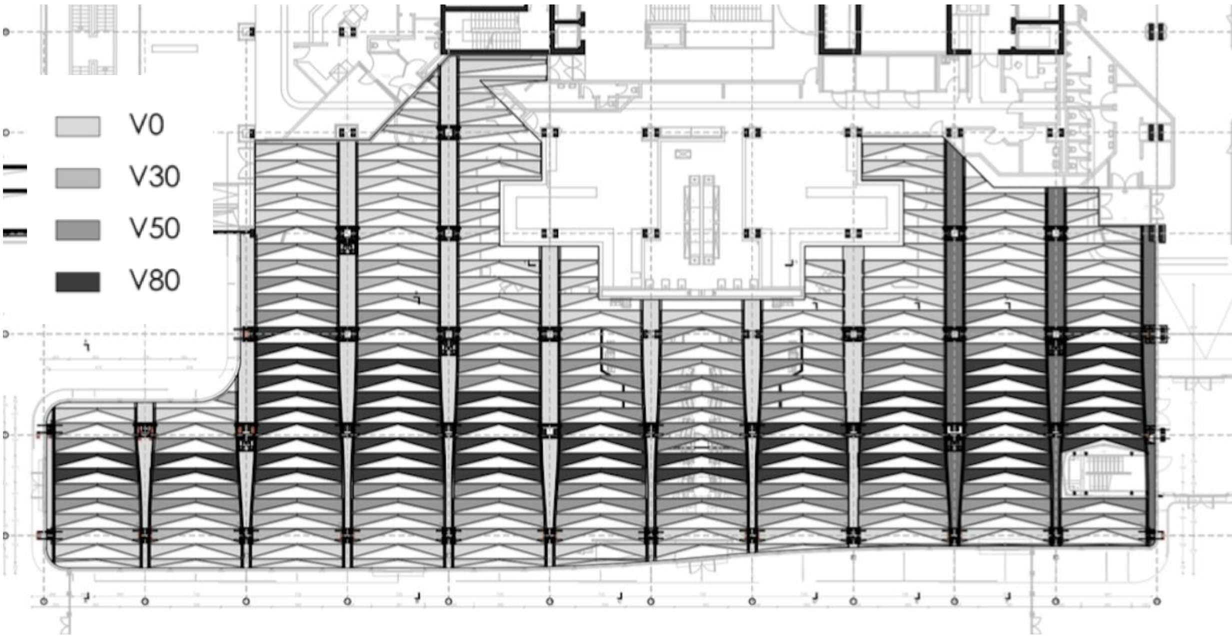

Figure 7: Plan of the restaurant and distribution of the sails in the room.

ACOUSTIC ANALYSIS

The main purpose of the acoustic design was to make the room the most absorbent on the ceiling as we could, in order to have a low reverberation time and a good speech intelligibility. Table 1 (left) shows sound absorption coefficients of the materials in the restaurant. We studied the room acoustic behavior with CATT-Acoustics software, and we verified that the sound field in the room, using the textile system, satisfied the reverberation time optimal value, according to the Sabine, Eyring and Arau-Puchades’ formulas and the Ray tracing method. We checked also the speech intelligibility. The reverberation time limit value, depending on the volume and the destination use (speech), is around 1.1 sec. Table 1 (right) shows the acoustic analysis results. The system is very performing and can improve the indoor comfort, reducing the reverberation time below the limit value. In order to analyze the room speech intelligibility, we used the software. We placed one speaker (male voice with normal vocal effort) and one receiver per table, far each other 0.7 m and at a height of a 1.2

m. We evaluated the speech intelligibility index (STI) in three different percentage of people sitting in the dining hall: 30%, 50%, and 70%. The simulation results show that for each percentage of occupation, the medium values of STI achieves an appropriate levels of intelligibility (STI>0.45). In particular: for an occupation of 30% (222 people, 37 speakers) we obtained STI=0.67; for an occupation of 50% (360 people, 60 speakers) we obtained STI=0.58; for an occupation of 70% (528 people, 88 speakers) we obtained STI=0.54.

Absorption	**Frequency (Hz)**						
Materials	**m^2**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Linoleum	1800	0.02	0.02	0.03	0.03	0.04	0.04
Plaster	561	0.02	0.02	0.03	0.03	0.03	0.03
Mineral wool	1800	0.18	0.63	0.85	0.97	0.93	0.96
Glass	605	0.18	0.06	0.04	0.03	0.02	0.02
Rock wool	1422	0.18	0.77	1.01	1.04	0.97	0.97

RT	**Frequency (Hz)**						**θm**
Methods	**125**	**250**	**500**	**1000**	**2000**	**4000**	
Sabine(1)	1.77	0.56	0.43	0.39	0.41	0.41	0.66
Arau-Puchades(1)	1.67	0.6	0.44	0.41	0.45	0.44	0.67
Sabine(2)	1.85	0.61	0.46	0.43	0.44	0.41	0.70
Eyring(2)	1.74	0.49	0.34	0.31	0.32	0.30	0.58
Ray tracing(2)	2.31	1.09	0.49	0.56	0.48	0.44	0.90

(1) results of the hand calculation; (2) results of the software simulations.

Table 1:Sound absorption coefficient of the materials (left) Values of reverberation time (RT) according to the Sabine, Eyring and Arau-Puchades' formulas and the Ray tracing method (right).

CONCLUSIVE REMARKS

In this research an innovative false ceiling system has been studied. This kind of system, adaptable for design and acoustic performances, has been used for the false ceiling installation in the Centre Hospitalier Universitaire Vaudois restaurant. It is very important to have comfortable working places, so it is important as well to design a system that could reduce the room reverberation time. The system, designed for the "case study", is made of suspended shaped panels and is high performing because of its double exposed surface. We have studied in depth the restaurant acoustics with CATT-Acoustic software simulation in order to see how the system worked in terms of reduction of reverberation time, using the Sabine, Eyring and Arau-Puchades' formulas and Ray tracing simulation. Results show that the system, in addition to having a nice and unusual appeal, can really improve the indoor comfort, reducing the reverberation time, even if the room is crowed and characterized by reflective surfaces.

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