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VARIABLE ACOUSTICS OF THE INTESA SANPAOLO TOWER'S AUDITORIUM

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ABSTRACT

The Intesa Sanpaolo Tower was completed in 2015 in Turin. It features a multipurpose auditorium with a seating capacity ranging from 336 to 364 people depending on the configuration. The auditorium can host any kind of events from classical concert to conference and in order to have optimal acoustic conditions for the different type of events, variable acoustics was implemented inside the auditorium. PEUTZ & Associés designed the acoustics of this extremely versatile space along with the architects RPBW. The variation of the acoustic response is based on the changing inclination of the audience and rotating acoustic panels. During the design stage, acoustic 3D calculations were carried out and at the end of construction, final measurements were made to check compliance with the acoustic requirements. This paper describes the design process and the results that have been achieved.

Keywords: *auditorium, variable, MLS*

1. INTRODUCTION

Today the auditorium is an important place for the cultural life of Turin. According to the data provided by Intesa San Paolo, from 2015 to 2022 it has hosted 280 events of which 60% were congress or press conference, 15% author readings (with amplification), 5% amplified concerts, 5% unamplified concerts and 15% others (exhibitions, visits, etc…). The acoustics quality of the auditorium has been praised by users, sound directors and public (50000 persons since 2015) even though the auditorium is not used to its maximum extent. For example, the seated flat configuration is not yet used for concerts, and for speech sound amplification is always used.

2. FROM USER'S BRIEF TO TECHNICAL PROPOSAL

Initially, the auditorium was described by the project brief as the congress hall for the Intesa Sanpaolo group, but the possibility of multifunctional use was mentioned since the beginning. Indeed, the client explicitly expressed the will to have a hall capable of hosting classical recitals in very good conditions, but also to use the hall in a "flat" configuration with no seats.

In other words, on one side a very intelligible hall was needed for congress use, but on the other side, a lively and immersive hall was desired for concerts. Above this, the seats had to be removable for special events.

As opposite acoustic conditions were required for the different uses and flexible seating and stage configurations were necessary, a versatile hall with variable acoustics was contemplated from the start.

The architects and scenographers strongly supported this solution which extended the technical and formal possibilities.

3. DESIGNING THE AUDITORIUM

When it comes to unamplified music, the first parameter to be defined is the volume.

For classical recitals or chamber music ensembles, the optimum volume to achieve a good balance between reverberation and acoustical strength is typically between 4000 m^3 and 7000 m^3. This was the starting point to design the auditorium which is characterized by a square plan

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surrounded by two levels of galleries. By including the galleries in the volume of the auditorium, it was possible to achieve a volume of 5000 - 6000 m^3 with a very open relation between the hall and the corridors so that it would behave as a unique acoustical volume. Without any absorbing surfaces except the seats, our preliminary calculations indicated we could achieve a reverberation time between 1.6 s and 1.8 s from 250 Hz to 2000 Hz which is the preferred value for recitals or small ensembles. The volume was calculated with a flat audience which is recommended for concerts because it enables the walls around the audience to provide multiple reflections in the horizontal sound field, thus providing a spatial and surround sound quality.

Now the challenge was to transform the hall into a hall that would also be suitable for conferences.
The most important criterium for this kind of use is speech intelligibility and this would require totally different acoustic conditions: direct sound and early reflections should be dominant over the late reflected sound, which implied having absorbing surfaces to reduce late reflected sound and changing the inclination of the audience to increase direct sound, increase the absorption as seen from the stage and reduce the first order rear wall reflections back to the audience. Changing the inclination of the audience would also be a way of reducing the volume of the hall with 500 m^3 approximately, which would contribute to reduce reverberation as well.

At this point all the acoustic principles were clear to the design team: the hall would need to have a modular geometry and absorption variability.

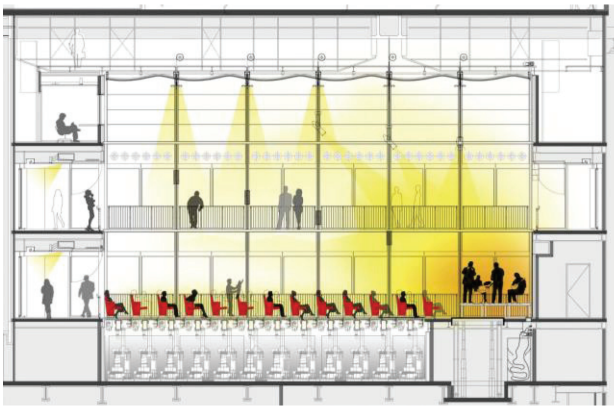

Figure 1. Vertical Section on hall – concert configuration

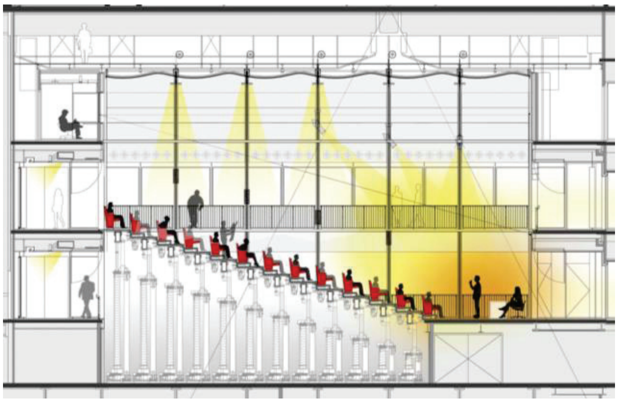

Figure 2. Vertical Section on hall – conference configuration

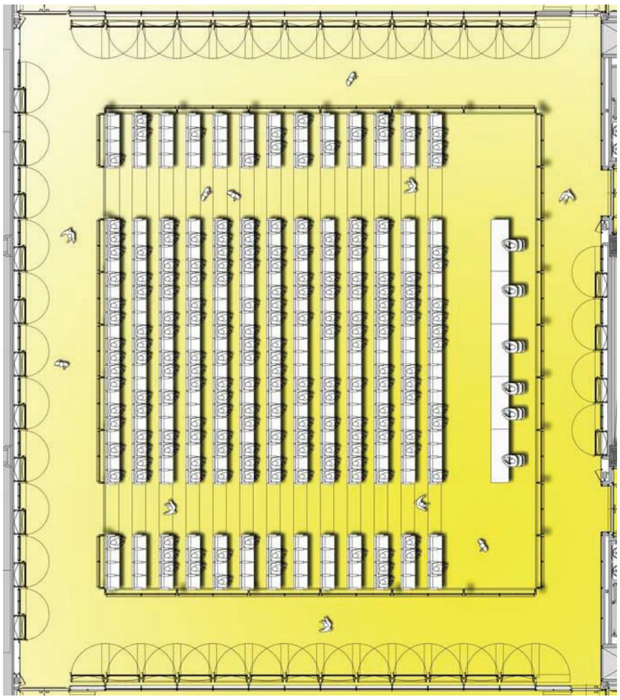

Figure 3. Horizontal Section on hall – rotating panels

4. TECHNICAL SOLUTIONS

4.1 Flexible audience configuration

For the audience, a system based on independent moving platforms for each row allows to change the inclination of the audience and to store all the seats below the platforms for standing events (see Fig. 1 and Fig. 2).

4.2 Acoustic panels

Fixed and rotating acoustic panels are installed on the walls of the corridors surrounding the hall. Rotating panels have an absorptive side with slatted wood finish and a reflective / diffusive side with a fabric finish.

Behind the fabric some wave-like convex curved metal panels scatter energy in the horizontal direction to improve spatial impression. A heavy bituminous membrane is fixed to the back of the metal panels to reduce low frequency absorption and to prevent feedback to the hall from resonating metal.

On lateral walls all the panels can rotate whereas on the front and rear wall, fixed and rotating panels alternate. When the rotating panels are flipped over the fixed panels a 50 cm deep wave-like pattern is created resulting in a very diffusive pattern as wanted for rear and front walls in the concert configuration (see Fig. 4).

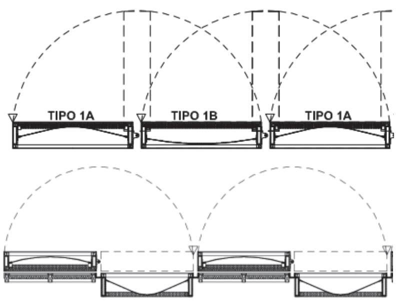

Figure 4. Rotating panels on lateral walls (up) and front and rear walls (down)

The choice of a fabric finish by the architect for the reflective side was a challenge. The openness required for an acoustical transparent layer conflicted with the architectural concept. Even though the fabric was very carefully selected, the reflective side is still slightly absorptive. The absorption characteristic is rather flat in the frequency range, thus maintaining the spectral balance in the hall. However, it reduces the possible amplitude of sound absorption variation.

4.3 Upper walls of the hall

Within the hall the walls of the third level are reflective with a flat wood finish and come flush with the control room's glazing. These walls provide only late reflected sound by multiple reflections and the diffusion is provided by other surfaces, for instance the ceiling.

4.4 Auditorium Ceiling

The auditorium ceiling is reflective and diffusive.
To cancel risks of echoes coming from the ceiling and to soften the intensity of ceiling reflections to enhance lateral sound field, a strongly diffusive ceiling was preferred. It consists of a wave-like ceiling with a wood finish.

5. ACOUSTIC MEASURMENTS

Measurements were made over 10 source-receiver positions to determine the acoustic indexes of the hall in the 2 main configurations:

- concert: flat audience and reflective panels
- congress: sloped audience, and absorptive panels

5.1 Reverberation time measurements

The results are presented below:

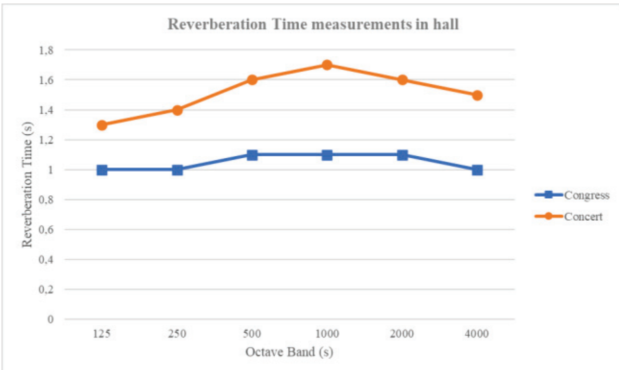

Figure 5. Measured reverberation time

For the congress mode the reverberation time is about 1.1 s (unoccupied) which is good and corresponds to the requirement. For the concert mode, the reverberation time is around 1.6 s from 500 Hz to 2 kHz which is the low-end value of the objective, but still very well suited for chamber music. At low frequencies, the reverberation time is slightly lower resulting in a very clear and pleasant hall to play in.

5.2 Speech intelligibility and clarity

We have made impulse response measurements with a MLS (Maximum Length Sequence) signal in the auditorium to determine other acoustic index such as intelligibility and clarity.
The mean values ($\bar{x}$) and standard deviation (s) are presented here below:

Table 1. Mean value and standard deviation of speech intelligibility STI (without background noise) and clarity C80

	STI		C80 (dB)	
	$\bar{x}$	s	$\bar{x}$	s
Concert	0.53	0.02	-0.6	1
Congress	0.61	0.01	3.0	0.7

In concert mode, STI is around 0.5 and values are rather homogeneous over the audience. Speech intelligibility is fair even though the configuration favors musical comfort.
Clarity C80 is negative in almost every point which means a pleasant sensation of immersion and spaciousness will be experienced by the listeners.

In the congress mode, STI is above 0.6 in every point of the audience with a very little standard deviation which means intelligibility is good and constant over the audience. This value makes it possible to use the hall without amplification given the short distance between the stage and the last row (15 m approximately) which allows to achieve a sufficient signal-to-noise (S/N) ratio.
Clarity C80 becomes positive which is coherent with the fact that direct sound and early reflections become dominant over late reflections.

5.3 Impulse response

The impulse response IR measured with the MLS signal for each configuration is compared hereafter at 1000 Hz for one source-receiver position (source on stage at 1/3 of width and receiver in the middle of the audience at 1/3 of the width on the opposite side):

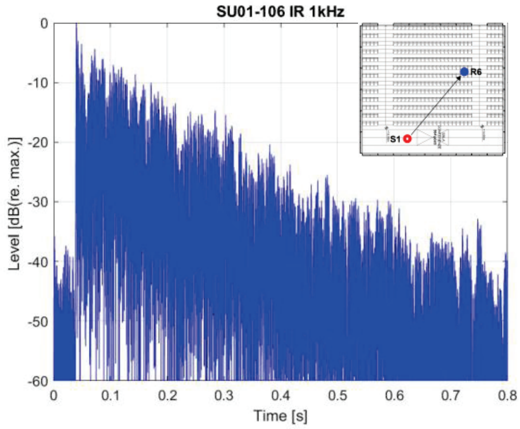

Figure 6. IR at 1000 Hz in Congress mode

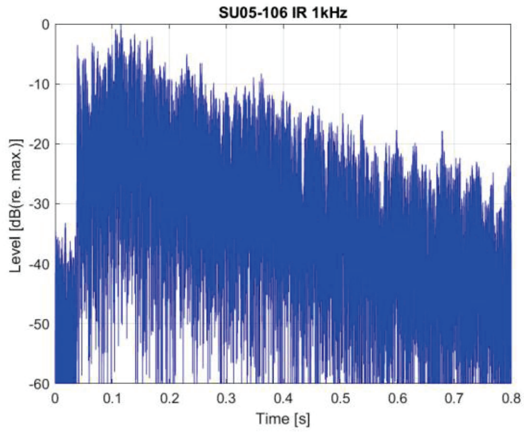

Figure 7. IR at 1000 Hz in Concert mode

From the impulse response analysis, we can see clearly that in the concert mode, the density and intensity of early sound reflections generate an increase of sound level after the arrival of direct sound. The sound is sustained thanks to the combination of increasing lateral reflections and reducing absorption as seen from the stage (flat audience). It then decreases slowly and homogeneously, resulting in a lively hall which is perfectly suited for chamber music.

In the congress mode, the impulse response is totally different. After the arrival of the direct sound, the sound level decreases quickly and constantly. This favors high definition and speech intelligibility.