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Acoustics of the Teatro dell'Accademia delle Arti in Tirana (Albania) - spatial sound analysis

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ABSTRACT

The Theatre of the University of Arts of Tirana was realized in the early 20th Century in Tirana based on the design of the Italian architect Bosio. It was almost abandoned in the last 20 years and only recently has undertaken a complete restoration, including the design of a new orchestra pit. Acoustic measurements (monoaural and bin-aural IRs) were conducted to calibrate the 3D model and to elaborate the new acoustic design of the theatre. The paper briefly reports the story of the theatre and the most important outcomes of measurements and simulations.

Keywords: Theatre, Reverberation Time, Acoustic design.

1. INTRODUCTION

The Theatre of the University of Arts of Tirana has been involved recently by a project for the restoration and renovation that has been carried out by the Department of Architecture of the University of Florence together with the engineering study Atelier4 of Tirana. The supporter of the study was Trans Adriatic Pipeline, TAP, with the agree of the Ministery of Culture of Albania.

In this paper some of the acoustical investigations performed on the hall are shown, in order to ensure optimal room acoustics after the restoration works.

2. THE CONCERT HALL AT THE UNIVERITY OF TIRANA

2.1 About the history

The origin of the Opera Dopolavoro Albanese in Tirana dates back to the period between 1939 and 1943. During these years, the city underwent a building and territorial transformation that changed Tirana landscape from a small original city, with a prevalently residential layout, into an urban complex that better reflected the image of a capital city.

As part of this political, social and urban planning project that affected the whole of Albania, some Italian architects, mainly from Florence, guided by Gherardo Bosio, were called upon to contribute actively to the transformation of the city of Tirana.

The Theatre, designed by Bosio and developed by collaborators after his suddenly death, reflects that language of classical matrix, made of regular geometries, rhythmic repetitions, and functional expressions, which belong to the Italian architecture of Rationalism and that constantly characterize the work of the author.

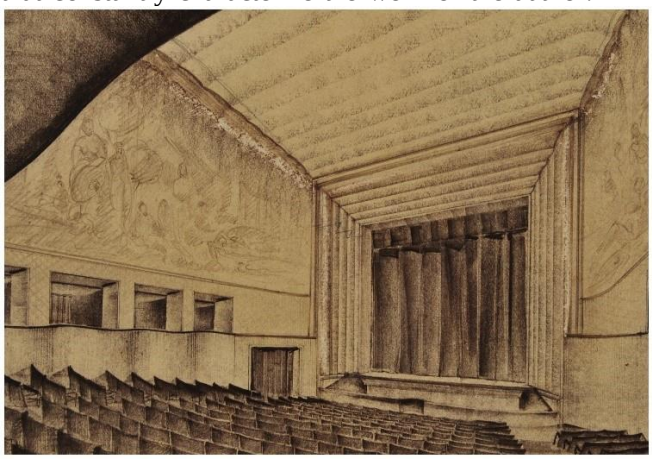

Figure 1 – Original drawing of the theatre.

Even though the settlement of the city has changed over time, as well as the surrounding area of the theatre, where today we find many other architectures close to the building which have lost the original linguistic strength, the Opera Dopolavoro Albanese, inside which we find the Concert Hall of the University of Arts, and

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the other architecture and boulevards of the same years are still a fundamental part of the historical identity of the city of Tirana. In fact, the building is currently considered as part of the Historical Heritage of Monumental Axis of Tirana: it's located in the historic centre of the city, within an area of national importance, declared protected since 2017, as architectural, cultural, heritage of XXth Century.

2.2 About the theatre

The hall of the theatre has a volume of about 5000 m^3 and is characterized by the presence of a platea surmounted by a gallery, both flanked by an order of double lodges. Both platea and gallery have a similar number of seats.

The scenic tower is composed of superimposed orders of rooms and technical rooms and the stage, with orchestra pit below.

Considering the volume of the hall, the optimal reverberation time should be between 1.3 s (for operas and theatrical performances) and 2.4 s (for classical music).

2.3 The aims of restoration project

The main aim of the feasibility study led by the Department of Architecture of the University of Florence was to define a line of restoration and refurbishment of the Theatre to identify, bring to light and protect the constructive and language characteristics of Bosio's project, and at the same time to guarantee an optimal and safe use of the building, in terms of technological and legislative adaptation, usability and accessibility, minimizing as much as possible the alteration of the original identity of the theatre (figure 2).

Figure 2 – rendering of the restored theatre

The main specifications for the acoustic project of the restoration of the theatre concern the reduction and restoration of armchairs, the replacement of curtains and the restoration and enlargement of the orchestra pit. To achieve this increase of the size of the pit, the floor plan was significantly modified from its original dimensions. It was also foreseen the installation of a mobile platform in order to vary the height of the orchestra pit according to the needs of the performances.

3. MESUREMENTS PROCEDURE

The impulse response measurements were carried out in the theatre on February 2020 in accordance with the requirements given by the standard ISO 3382-2. Both a single omnidirectional microphone moved from one position to the next (for monoaural measurements) and a pair of headset microphones (for binaural measurements) were used.

Two different types of fixed sound sources were used for sound emission:

- the theatre's loudspeakers for the reproduction of the "sine sweep" audio signal generated by the PC and reproduced by the theatre's amplification system; in this case, the measurement procedure used is that of the generation of a "sine sweep", then convolved by means of the plugin "Aurora" for Audacity® into a corresponding impulse response; the position of the two loudspeakers was that envisaged by the theatre (frontal, lateral to the stage, figure 3, S2 a and b);
- an impulse source consisting of the bursting of balloons with a diameter of 40 - 45 cm; the balloons were all burst from the stage at the position shown in figure 1 (figure 3, S1).

Care was taken to maintain a random and non-symmetrical distribution of microphone positions during the measurements (figure 3).

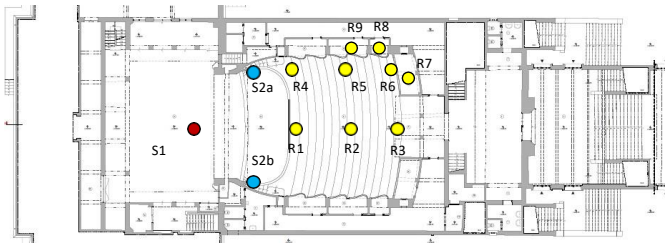

Figure 3 - Source positions and measurement positions in the platea (R1 - R6), in the central stage (R7) and in the lower side lodges (R8 and R9); S1 = position of the impulse source; S2a,b = positions of the two loudspeakers. Measurement positions R10-R12 were placed in the galleria and in the lateral lodges.

4. MESUREMENTS RESULTS

Using the two measurement methods described (impulsive noise and sine sweep), the impulse responses were obtained at the different locations and in both omnidirectional monaural and binaural modes. The following parameters were then analyzed (12 measurements x 2 methodologies = 24 measurements):

- Reverberation time T_{30};
- Clarity C_{50};
- Clarity C_{80};
- Barycentric instant ts;

- Early Decay Time EDT.

Moreover, also Speech Transmission Index measurements were carried out.

The results referred to the 12 measuring points of T_{30} and C_{80}, measured with the sine sweep technique and the omnidirectional microphone, are shown below.

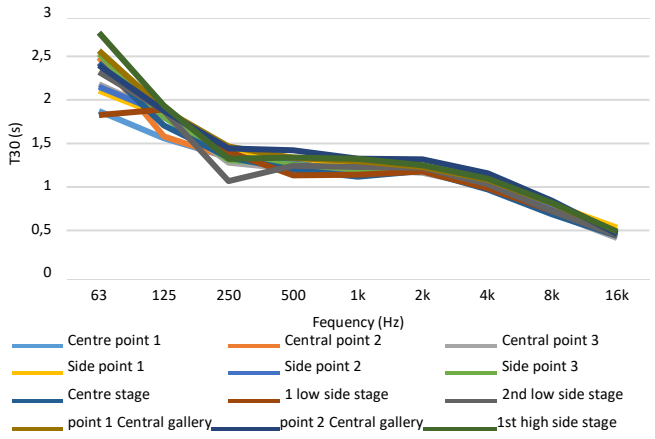

Figure 4 - Reverberation time T30 in octave frequency bands at the 12 measurement locations.

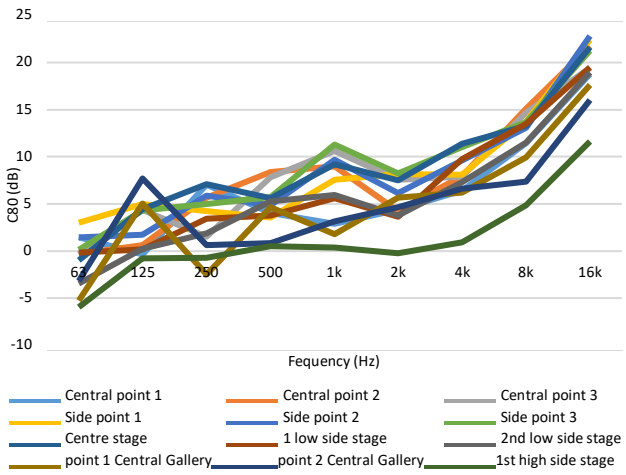

Figure 5 - C80 clarity in octave frequency bands at the 12 measurement locations.

5. DISCUSSIONS

Figure 6 shows a comparison between the average values of the reverberation time at the 12 measuring points obtained with the two techniques.

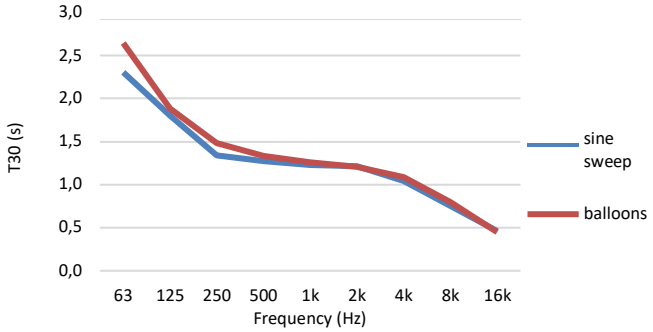

Figure 6 - Comparison of average T30 results with the two measurement techniques adopted.

A good repeatability of the measurement results obtained with the two signal techniques can be observed.

Moreover, the average values of T_{30} obtained at the different locations are quite repeatable and therefore "stable". Figure 7 shows the values of the average reverberation time, T_{30}, in the six platea positions, the two galleria positions and the lodges.

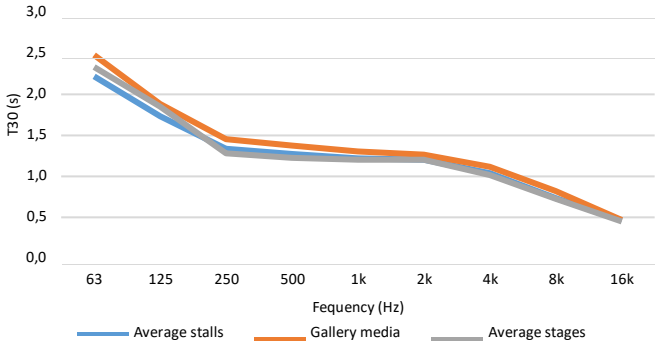

Figure 7 - Average value of the reverberation time T_{30} in the platea, galleria and lodges.

Considering the theatre's volume of approximately 5000 m^3 and referring to the value assumed by the reverberation time at 500 Hz it can be considered that the theatre has a rather "dry" acoustics, i.e. it has a low reverberation that is well suited to theatrical performances and listening to speech.

With regard to listening to music, for which a greater contribution of reverberation is normally required, the theatre is probably a little "dull" at high frequencies, i.e. it has a slightly too low reverberation time.

6. CONCLUSIONS AND INDICATIONS FOR THE RESTORATION PROJECT

The most relevant acoustic changes connected with the renovation project of the theatre were:

- restoration and reopening of the orchestra pit;
- reduction of seats in the platea by about 35%;
- reduction of seats in the galleria by about 30%;
- refurbishment of all plants and of all interior finishes of the theatre (plasters, stuccos, etc.);
- elimination of the carpets of the galleria;
- elimination of the curtains of the lodges.

The main aim of the restoration project was the conservation of the actual acoustics of the theatre that is considered one of the best in Albania, in terms of acoustic response. At this purpose, in agreement with the design team, the main acoustics issue of the project were:

- the design of the new orchestral pit;
- the design of the new rehearsal open space under the stage;
- the selection of the new theatre armchairs;
- the selection of the new curtains;
- the description of the acoustic requirements of windows and doors.

The main acoustic design efforts concerned the

renovation of the orchestra pit that was closed and not used during the last decades. The following indications emerged from the analysis of the measurements results and from the simulations: the side wall of the orchestra pit must be lined in wood, as currently; also the floor of both the platform and the covered part of the pit must be in wood; moreover it was necessary to apply sound-absorbing material in the ceiling of the covered part of the pit, for the increase in the sound pressure level that could characterize this space. It was provided a solution of a panel with three different configurations to modify the acoustic response inside the orchestra pit according to the requirements given by the orchestra director (figure 8).

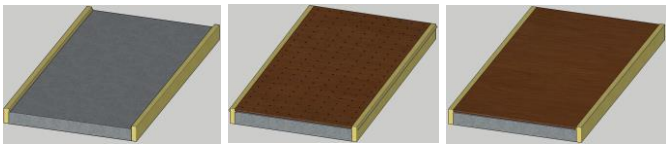

Figure 8 – Left: high frequency sound absorbing panel (not covered by the wood panel); center: low frequency sound absorbing panel (covered by the drilled wood panel); right: sound reflecting panel (when covered by the smooth wood panel).

Also the parapet, that separates the orchestra pit from the platea, has a very important acoustic function, to reflect the sound rays coming from the stage and the pit (figure 9). For this reason, it's advisable to pay attention to its structure, inclination and material.

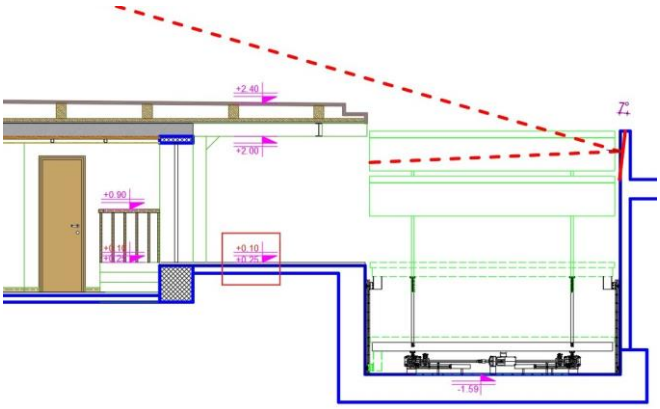

Figure 9 – Design of the parapet of the orchestra pit to improve the propagation of sound from the orchestra pit toward the stage and vice versa.

All existing armchairs will be replaced with others, made on the model of the currently ones present in the gallery, in accordance with Bosio's original project. New armchairs must not have an equivalent acoustic absorption area (A) lower than the current ones (0.44 m^2 at 500 Hz frequency).

In order to maintain an acoustic response similar to the current one in the lodges, where the curtains will be removed, it was also necessary to insert sound-absorbing panels on the lateral walls inside them.

According to the results of the simulations based on the measurements results described in previous paragraph, the acoustic response of the room was slightly more reverberating at the medium frequencies (figure 10). However, this modification falls within the limits of tolerance and uncertainty of the calculation method and in any case should not alter the acoustic perception in the theatre compared to the current condition.

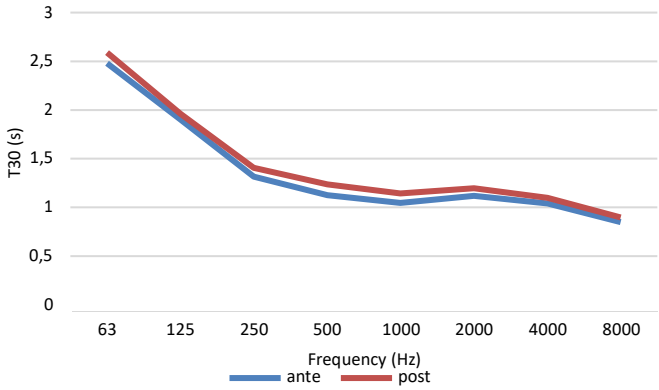

Figure 10 - Comparison of average T30 results before and after the restoration project (simulations).

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