The Acoustics of Ancient Theatres Conference
Patras, September 18-21, 2011

ANALYSIS OF THE ACOUSTIC PARAMETERS OF THE BASILICA "SANTA MARIA" ON THE PERFORMANCE OF THE MEDIEVAL LITURGICAL MASTERPIECE "EL MISTERI"

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Abstract

Our research is focused on the famous liturgical representation that takes place at the ancient Basilica "Santa Maria" located in the Spanish city of Elche. That representation known as "El Misteri" is more than five centuries old, and many years ago became singular for being the only representation performed at a religious stage in the world. Due to this, UNESCO declared it one of the Masterpieces of the Oral and Intangible Heritage of Humanity in 2001. The play has a religious character and shows historical situations of the Bible. It's performed only by males and the female characters are played by children. That's an important detail of the project so we study the acoustical differences caused by the voices.

Our project is based on the research of the room acoustics of that ancient stage applied to the performance of the liturgical piece. Furthermore we will study how the acoustic problems were solved in the Middle Ages. During the play there are many points of sound emitters, as the stage has two levels: the horizontal "terrestrial" stage and the vertical "celestial" stage, characteristic of the medieval mystery play. Actors sing and play instruments from hanging equipment in the air, so the Basilica will be studied as a 3D Stage. Experimental tests have been developed and modeling software will be used to validate the acoustical parameters like Reverb Times (EDT) and represent the behavior of the building. The software simulation will help us to make auralizations, simulating the effect of different sounds in different emitter points. In this manner we distinguish the Basilica and the stages (parts of the play with different sound point emitters). After studying the character of the play (kind of voices, their positions, instruments used, etc.) now we can apply the parameters to the model and obtain the simulation results.

Keywords

Auralization, Basilica, 3D Stage, "El Misteri", medieval performance.

1. Introduction

"El Misteri d'Elx" is a liturgical drama that since the mid-fifteenth century has been performed in the Basilica of Santa Maria on August, in Elche, Spain. It is a living testimony of European religious theatre that during the Middle Ages was performed inside religious places, although later were banned by the Council of Trent. Thanks to Pope Urban VIII, who in 1632 conceded a papal bull to the village of Elche to continue such representation, "El Misteri d'Elx" is the unique performance of its genre that has been performed without interruption until the present inside a place of worship. Due to this exceptional feature, in 2001 UNESCO declared it one of the Masterpieces of the Oral and Intangible Heritage of Humanity [1].
The representation recreates the death, the passage into heaven (known as the Assumption) and the crowning of the Virgin Mary [2]. All the characters (apostles, Jews and celestial figures) are performed by males, even the female characters are played by children (Virgin, the Marys, Angels and other celestial figures), since the medieval liturgical theatre did not allow female participation.
The performance is entirely sung, the organ provides piped music, without any help of electronic amplification, so the sound spreads naturally through the Basilica. The drama contains melodies that come from different eras: Middle Ages, Renaissance and Baroque. The melodies of "El Misteri" can be classified in monodic and polyphonic, and they are collected at the *Consuetas*.

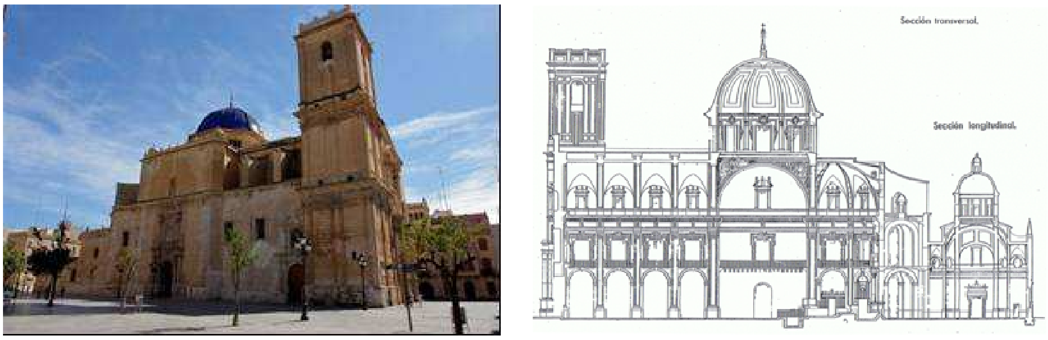


Figure 1 – The Basilica of Santa Maria of Elche and Cross section of the Basilica

The Basilica was built in a Latin Cross shape, first building in 1556 and current one in 1672, see figure 1, [3] organized in one nave divided in four sections, with side chapels between the buttresses and interconnected, and a short crossing surrounded by an ambulatory which gives access to the chapel of the Communion. On one side, between the main body of the building and the chapel of the Communion, lie the sacristy and the staircase that leads to the upper corridors. The interior of the nave is enclosed with a barrel vault interrupted by arches. The stone used in its construction is calcareous sanstone from a quarry located northwest of the city.
Above the crossing stands a large dome that during the representation of "El Misteri" is covered with a canvas at the ring level that serves two functions: to represent the sky and to hide the mechanisms that allow the ascent and descent of the aerial devices.
The current Basilica, which was under construction for more than one hundred years, suffered some adaptations designed for the performance of "El Misteri", especially from the scenic point of view. For example, since 1686 when the nave was opened, until 1760 when the dome was used for the first time to represent the sky, the aerial stage machinery was mounted on the ceiling of the nave using a hole that in the documenta-

tion is reflected as the "door where the angel descends" and that was covered with a plank the rest of the year.

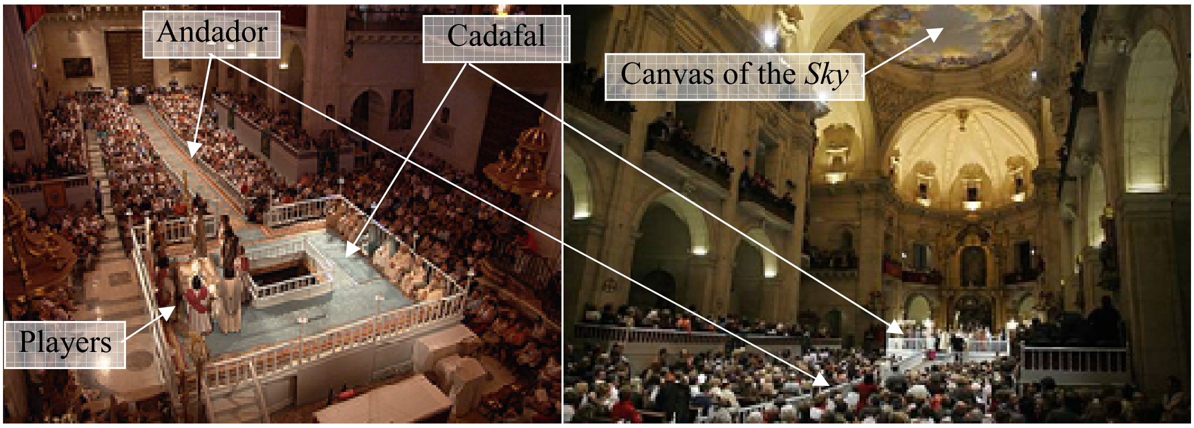


Figure 2 – The vertical and the horizontal planes and the scenic elements

From the acoustics point of view, the most important action was to move the organ. Originally, it was located above the main door of the temple, but in 1744 it was moved to the place that nowadays occupies. Probably, this moving was conducted to situate the instrument closer to the altar and the *Cadafal*, when in 1760 the dome began to represent the scenic sky. Although the organ is part of the performance, the rest of the sound sources (the actors and other musical instruments as guitars and harp), are in silence when it is played. The work presented in this paper is only focused on the human sound sources.

The stage created by the Basilica itself is divided into two parts: the vertical plane and the horizontal plane. The horizontal plane consists of a square-shaped platform, called *Cadafal*, which stands in the crossing slightly inserted in the presbytery. Its location, at the geometric centre of the church, allows viewers to stand on all four sides, according to the medieval tradition. This platform is accessed from the main door of the temple at the foot of the nave, by an inclined plane, called *Andador*, where most of the characters enter the scene. The vertical stage is installed in the dome of the church, symbolizing the sky. There is a small square-shaped opening, eccentrically positioned to the side of the presbytery, which can be opened and closed by sliding doors: "the gates of heaven".

The aerial devices, 3D stage, are three: the *Granada*, in which an angel descends to announce Virgin Mary its death; the *Araceli*, which looks like an altarpiece and carries five angels represented by three adults and two children; and the *Coronación*, an altar-like structure, similar to *Araceli* but smaller, that represents the Holy Trinity.

To carry on the present research, the performing surface has been divided in four stages, determined by the most distinguished moments of the liturgical drama. These stages are:

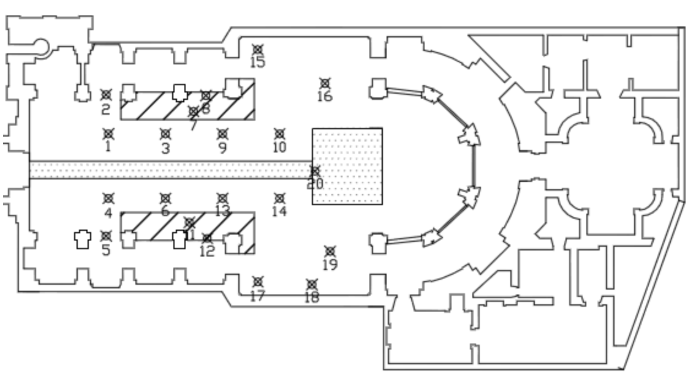
- Stage 1. The beginning of the *Andador*, where it is represented the scene of *El Ternari* that is performed by three male voices;
- Stage 2. The middle of the *Andador*, where a treble voice plays as the Virgin Mary;
- Stage 3. The *Cadafal*, where the most part of the drama is played and there are located twelve male voices;
- Stage 4. Halfway between the *Cadafal* and the canvas of the sky, where is situated a treble voice.

2. Objective

Due to the singular characteristics of the performance and the different stages, the aim of this research is to analyze the acoustic behavior of the Basilica and how it changes when the players move around. To reach this objective, experimental measurements and an acoustic simulation of the Basilica have been developed.

3. Measurement method

The experimental methodology used complies with the requirements of ISO-3382 [4] and IEC 60268 [5]. This section describes the methodology and the technical features of the equipment used to measure the reverberation time in the listening areas, emitting in the different stages.
During the measurements, an ominidirectional source was placed in each of the four stages defined in section 1, and reverberation time was captured in 20 receiver points distributed around the listening areas, see figure 3. ISO 3382 [4] suggests that receivers should be placed at 1.2 m above the floor, at a distance of 1/4 wavelength from any reflecting surfaces (corresponding to about 1 m), and at half wavelength from each other. However, the definition of the optimum placement of the receivers (capable of ensuring an accurate description of the variations of the acoustical parameters), cannot rely only on practical considerations but should take into account the actual distribution of the sound in the room.



Height of measurement points

h=1.2 m (floor)
Mp:1,3-4,6,9-10,13-19.
h=2.8 m (cadafal)
Mp:20.
h=3 m (boxes)
Mp: 7, 11.
h=8.4 m(balconies)
Mp: 2,5,8,12.

Figure 3 – Measurement points distributed around the listening areas

In order to acquire the reverberation time there was used an OmniPower Sound Source (twelve loudspeakers mounted on a dodecahedron), Bruel & Kjaer Type 4292L, a power amplifier, B&K Type 2734 and a sound level meter B&K 2260, see figure 4 a).

4. Validation and simulation

Experimental tests provide acoustical information (Rt) of discrete points inside the Basilica, average standard deviation of each measurement point is lower than 1 JND, just noticeable difference (5% for Rt)[6]. These results have been used to validate the virtual model and simulate the acoustic behaviour of the building, see figure 4 b). So, the theoretical simulation of the Basilica will provide acoustical parameters in all potential receivers, allowing the study of the sound quality in the different listening areas depending on the source position (for the different stages).

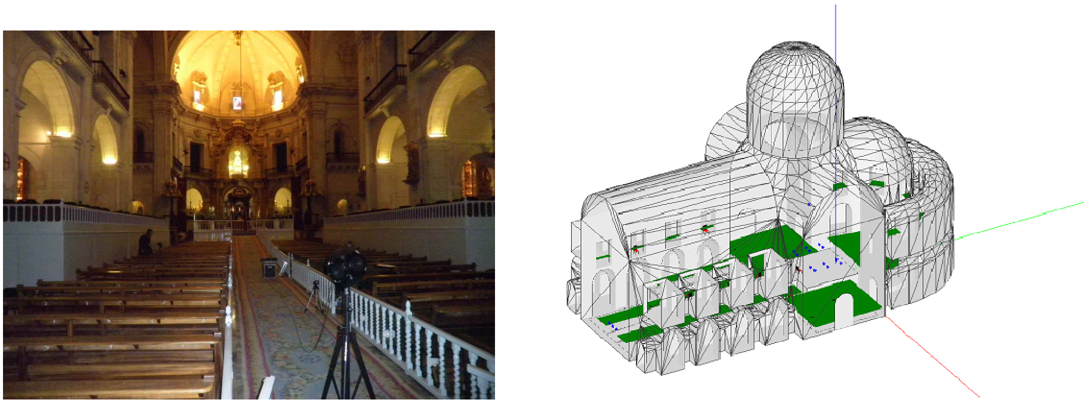


Figure 4 – a) Image of a measurement inside the basilica, b) 3D simulation of the temple

As was explained before, the church was built using local sandstone. The absorption of floor, structures, furniture and decoration is calculated on the basis of absorption coefficient of the materials (marble, wood, velvet) taken from bibliographical sources, but there is not previous information of the absorption characteristics of the sandstone. For that reason, experimental results were used to validate the theoretical model and adjust the absorption coefficient of the stone, 83% of the whole interior surfaces are made of this material (ceiling and walls). Minimum deviations are iteratively applied to these coefficients until the simulated reverberation times (for each frequency) do not differ by more than 10% from the values measured *'in situ'* [7].

The results of the iteration are shown in table 1.

Table 1 – Absorption coefficient of local sandstone

Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000
Abs Coef, α	0,07	0,08	0,08	0,09	0,09	0,09	0,1	0,1	0,1	0,1	0,1

Frequency (Hz)	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
Abs Coef, α	0,12	0,14	0,12	0,14	0,12	0,14	0,13	0,13	0,14	0,13

Simulation was developed by the software EASE. The geometric model of the Basilica contains a total volume of 21657.96 m^3, implemented by defining 3572 surfaces, see figure 4.

5. Theoretical and experimental results. Discussion

Eight acoustic parameters, Reverberation Times (TR30 and *EDT*), Brilliance (*Br*), Clarity (C_{50} and C_{80}), Center Time *Ts*, Strength Factor *G* and Intelligibility Parameter (STI), were analysed using the theoretical model (previously validated by experimental results). In current document there are just evaluated the clarity parameters (C_{50} and C_{80}). Comparisons were made between the selected acoustic parameters of clarity for each of the receiver locations in the room. Figure 5 shows how changes the musical clarity, C_{80}, in the listening areas depending on the stages, for the frequency band of 500 Hz. After analyzing all the listening areas, band frequencies of 500, 1000 and 2000 Hz, the average standard deviation in some locations is higher than 5 JND (1 dB for C_{80}).

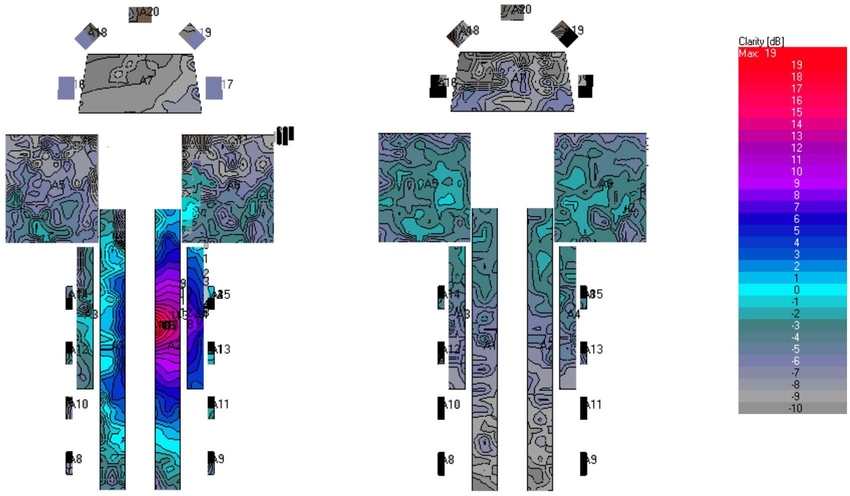


Figure 5 – Comparison of the $C_{80,\ 500\ Hz}$ parameter in the different listening areas for noise sources emitting in stage 2 and 4.

6. Conclusion

The exceptional feature of "El Misteri" as a sacred musical drama and the place where it is performed, justifies the acoustical assessment carried on in the present research. For that reason, experimental measurement and a theoretical simulation have been developed to analyze the acoustical behaviour of the temple and how it changes depending on the location of the players. As a result, even though the experimental dates of reverberation time have a uniform distribution in all the listening area, theoretical simulations point out the meaningful deviations of the clarity parameters due to the different stages used during the performance, see figure 5. As future actions, there is expected to use the simulation model to propose ornamental accessories to improve the uniformity of the acoustical parameters in the listening areas.

Acknowledgement

We would like to thank the Misteri-sponsored Chair of Miguel Hernandez University for allowing us to access to the Basilica and for their collaboration in the research.

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