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ACOUSTIC MEASUREMENT AND SIMULATION OF AN IMPORTANT SHRINE IN SICILY

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Abstract

This study was carried out to characterise acoustically the shrine of Altavilla Milicia (Palermo) and to evaluate the acoustic climate generate by his pipe organ. The important historical-architectural aspects were also considered.

An acoustic simulation was carried out after the measurement of the typical acoustic parameters of an ecclesial room (as prevue by the UNI EN ISO 3382\1997). Some procedure of intervention were identified to be able to ameliorate the acoustic of the shrine.

INTRODUCTION

In the V century the architect have important treatise able to chose a knowledge on sound reflection geometrical law.

At the end of 800 tanks to important studies of French mathematics acoustics was developed more then building acoustics.

Today, in many contemporary churches, built as a hearing place of speaking, acoustic conditions subject the believers at an important attention effort. To be able to assure a good word intelligibility is necessary to assure a minimum level of 65 dB(A) in the whole room. Often, expensive amplification systems become necessary.

Another method to improve the acoustic level inside the church is "to strengthen" the direct sound by means reflectors able to make the principle of directional reverberation. The reflected sound delay should not exceed 30 ms.

A simulation of the sound diffusion inside the SHRINE of Altavilla Milizia was carried out. The acoustic simulation was carried out after have measured the acoustic parameters "characteristic" of the shrine as provided by the UNI EN ISO 3382\1997 (Measurement of Reverberation Time of indoor rooms, ….):

SURVEY PROCEDURE

The acoustic survey of the shrine has been led by a multitude of complementary activities:

- the first one was aimed at gathering information about: geometry of the room, surfaces, materials acoustic characteristics, room utilization (liturgy, sacred music) so as to characterize the more important sources of sound of the room;
- the acoustic measure of RT and parameters concerning the room criteria was carried out (room acoustic characterization) for the current configuration. Measurements were carried out in a grid of points for the model calibration;
- 3D modelling of the room;
- choosing of absorbing coefficient of materials;
- acoustic simulations;
- feedback procedure for model calibration (comparison between RT measured with RT calculated) and modification of the acoustic model;
- final simulation;
- choosing of procedures for the acoustic adjustment of the room.

THE SHRINE

The shrine is showed in figures 1 and 2. The shrine dispose of a pipe organ as showed in figure 3.

Figure 1 - Façade of the Shrine

Figure 2 – Interior of the Shrine

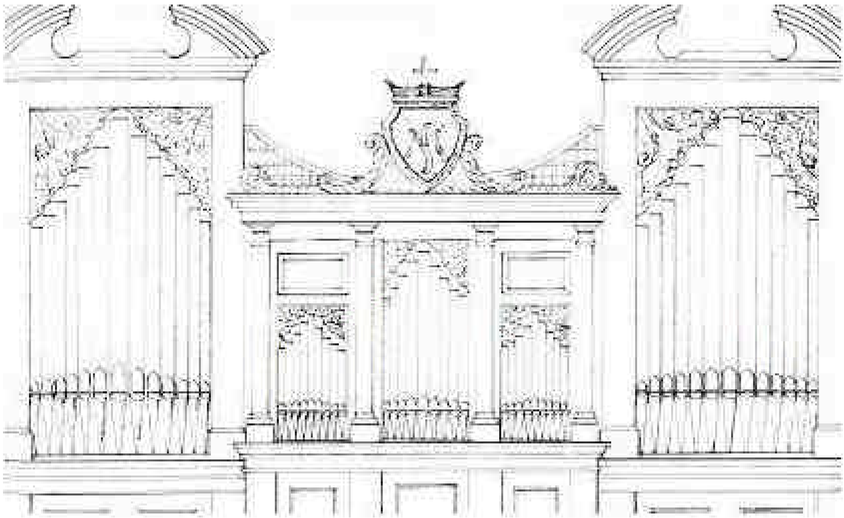

Figure 3 - Pipe organ of the Shrine.

The valuable instrument is placed inside a choir built up the main door. The pipe position is acoustically the best, because give an uniform sound diffusion inside the room (fig. 4).

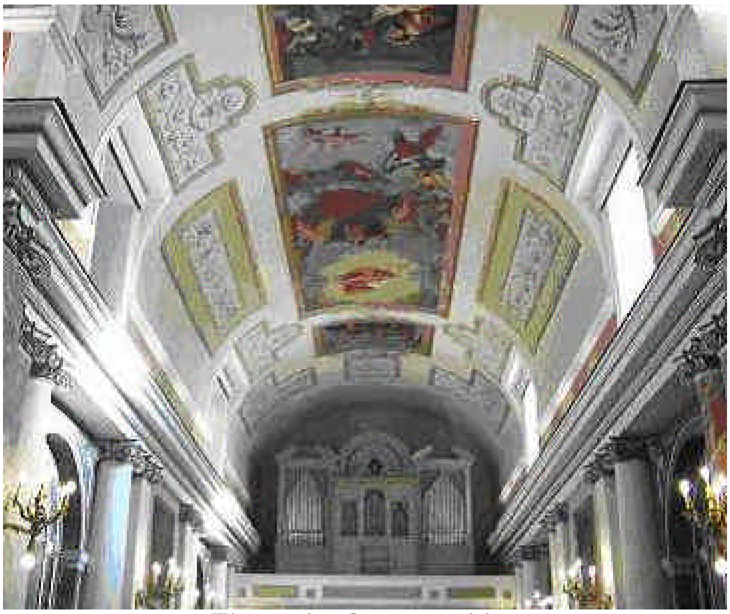

Figure 4 – Organ position

3D MODELLING

The 3D modelling give a wide range of performance analysis and simulation functions. The 3D modelling aide to conceptual design as well as final design validation. Designers can start generating vital performance-related design information before the building form has even been developed. It is possible to start with a detailed acoustic analysis to calculate the potential effectiveness of various passive design techniques or to optimise the use of materials. It is possible to test some scenarios before gradually developing up the final design. etc. The room shape was developed through extensive 3D computer modelling.

After drawn the model it is necessary to perform the material assignment. The effect of choosing a different material depends on the element type of the object. For objects such as walls, roofs, floors, and ceilings the incorrect evaluation of existing material or new materials (for a new project) could give errors estimated between 100% and 300%. For windows, doors, panels, voids, and sources could give also important errors of RT evaluation.

Material assignments is important in particular concerning the evaluation of absorption coefficients.

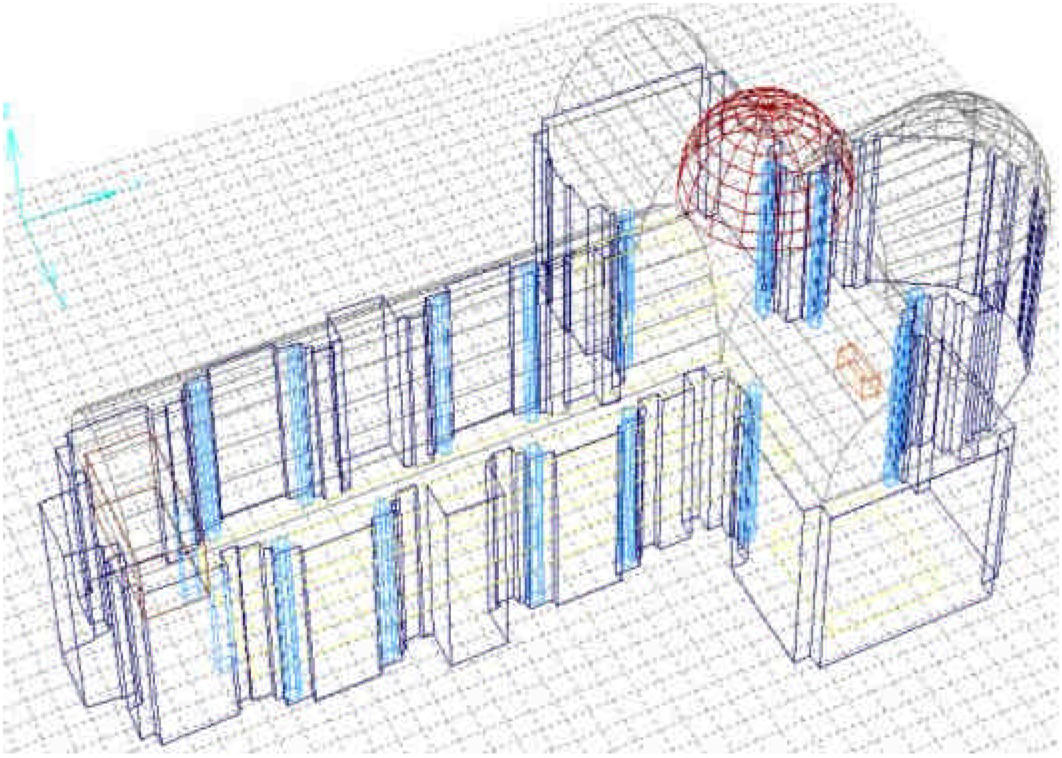

Figure 5 – 3-D model of the SHRINE

ACOUSTIC SURVEY

The experimental measurements has led us to characterize the hall in a grid of point. The sources (pipe organ and speaker) was placed as showed in figure 6.

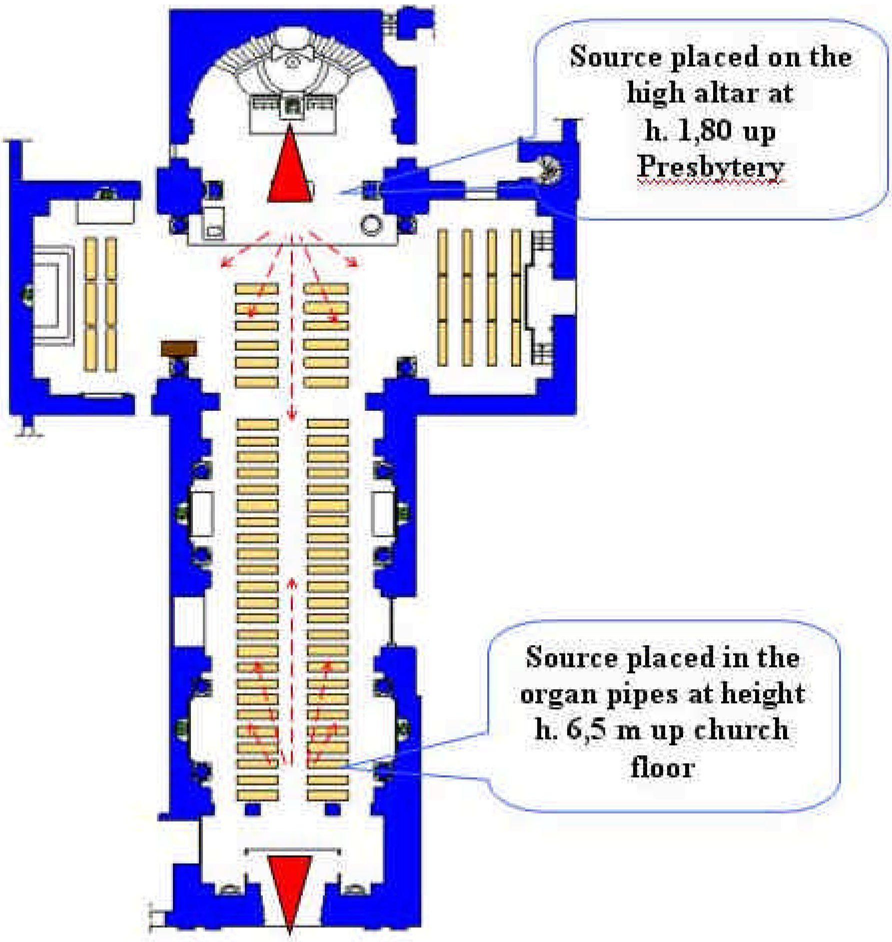

Figure 6 - Setting of two virtual sources

Reverberation time (RT) is the simplest and most commonly used objective measure of the acoustic performance of a space. It is defined as the time taken for the sound level of a steady source to drop by 60dB after it is abruptly turned off and is given as a value in seconds.

The RT is basically a ratio of the weighted sound absorption coefficients of materials within a space to its volume. The quickest method of calculation is simply to weight each material by its surface area - which is known as a statistical RT. This method takes no real account of the actual geometry of a space, just the materials within it and an overall form factor. However, it is usually a good predictor and is very widely used. An alternate method is to actually trace many thousands of acoustic rays randomly sprayed within the space and then to weight each surface by the number of ray intersections. This method usually produces different results to the statistical method as it focuses on the more acoustically significant surfaces and ignores those the sound can't actually get to.

As is usual with these things, the performance of the real room is likely to be somewhere between these two extremes. In this paper we are going to modify some materials within a space. In the following figure the results of RT measurement in a point near the main door are showed as an example (with the pistol shot placed near the altar).

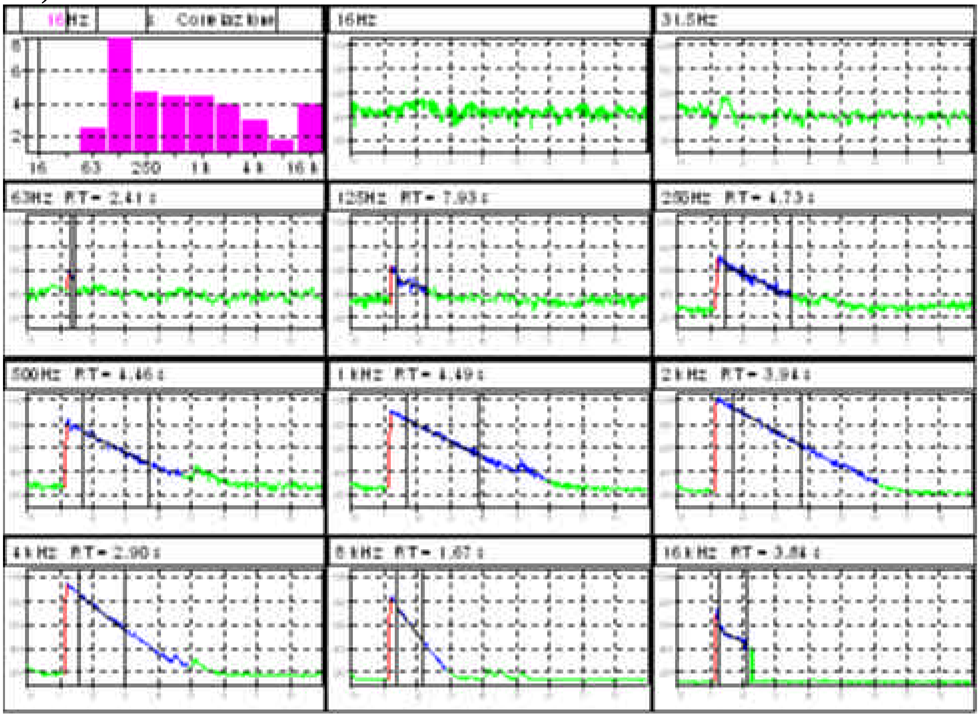

Figure 7 – Results of measurement

In figures the results of RT measurement in a point near the altar are showed as an example (with the central "DO" of the organ pipe).

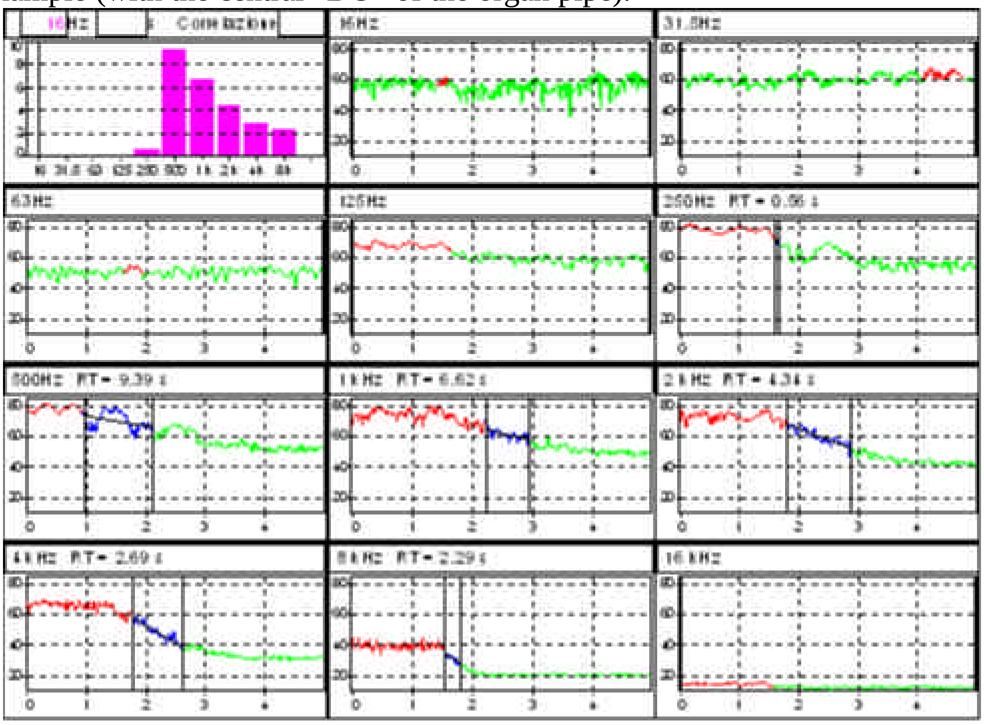

Figure 8 – Results of measurement

The simulation was carried out with a specific software. Here are showed as an example results of the simulation for the frequency of 250Hz.

SOURCE	FREQUENCY	T of deadening in ms
Pistol shot h. 1,80 m	**250 Hz**	**401,60**

In figure 9 sound rays after 21 ms are showed.

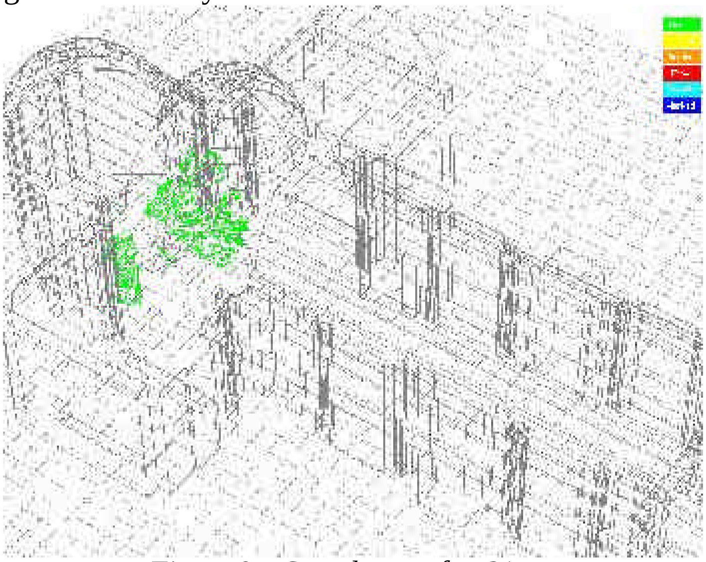

Figure 9 - Sound rays after 21 ms

Figure 10 shows the optimal TR for different room destinations function of the room volume and shows that for organ music the TR should be comprise between 2 and 3,5 sec.

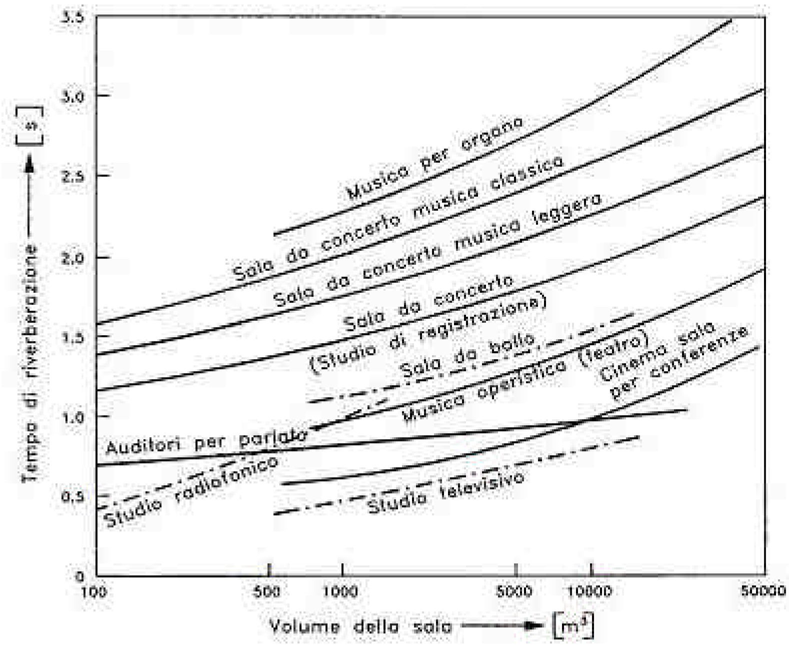

Figure 10 – Optimal TR for different destination

SUMMARY (OR CONCLUSIONS)

The acoustic space of the Shrine, taking into account the big volume and the low coefficient as sound absorbing of the surfaces, results characterised by a big TR not compatible with the exigencies of speech intelligibility or the good hearing of music.

We can affirm the church built to be a place of speech hearing is transformed into an obstacle for the hearing.

The reverberation cause a poor perception of a sound sequence, word or music, because sounds are masked by the sound tail of previous sound.

It appear the presence of geometric phenomenon, as source of physical interferences (reverberation, echo, amalgam, distortions, irregularity of hearing, acoustic shadow).

Some corrections of the room, compatibles with liturgical exigencies and with historic-architectonic constraint, were proposed.

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