

Churches Acoustic Investigation

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RESUMO: O presente estudo trata da investigação e análise de conflitos acústicos em ambientes construídos de igrejas, com sistema de sonorização e arquitetura moderna. Foram efetuadas medições in loco do nível de pressão sonora, do tempo de reverberação e da análise de frequências dos sistemas em utilização. As medições foram efetuadas com as igrejas vazias, e foram medidas a Igreja da Paróquia de Santa Maria Goretti e a Catedral Basílica Menor Nossa Senhora da Glória, ambas em Maringá – Paraná – Brasil. Objetiva-se a obtenção de dados que caracterizem a acústica específica da igreja (qualidade sonora, bem como o conforto proporcionado ao público), as possíveis causas de problemas acústicos identificando e relacionando-os com a resposta acústica.

ABSTRACT: The present study treats of the investigation and acoustic conflicts analysis of in churches, with sound system and modern architecture. Measurements were made of sound pressure level, the reverberation time and frequencies analysis of the used systems, inside the church. The measurements were made with the empty churches, in Santa Maria Goretti Church Parish and the Our Lady of Glory Cathedral Smaller Basilica, both in Maringá - Paraná - Brazil. We intend to obtain data to characterize the specific church acoustics (sound quality, as well as the public comfort) and the possible causes of acoustic problems and its relationship with the acoustic answer.

1. INTRODUCTION

The churches are constructions with objective to induce the assembly to a reflection psychic state, silence, concentration and prayer. In general, we can affirm that the ecclesial space, during the history, is not characterized by enjoying of good acoustic conditions.

In that context, the present paper looked for to identify the generating elements of acoustic conflicts as well as the specific church acoustics, relating them with the acoustic answer intra-church. For so much two measurements of sound pressure level were accomplished: one for evaluation of the generated sound by internal middle, where were analyzed the frequencies susceptible to problem, and another to obtain T-60 reverberation time.

2. MATERIALS AND METHODS

2.1 THE SOUND LEVEL MEASUREMENT WITH OCTAVE 1/1 BAND FILTER

To measure the level sound pressure was used the meter of level sound type 2, model SdB2+, from 01dB-Steel, with octave 1/1 band filter, temperature and humidity digital meter, model HT-3003, from Lutron and a reference sound disk, for evaluation of the back-ground noise inside buildings seeking the users' comfort. The measurement points are shown in the figure 1.

The measurements were made with the empty churches, being generated the pink noise in the sound system of each church, simulating the pressure sound level that was used in the celebrations. In Santa Maria Goretti church were measured 21 points and in the Cathedral 15 points. In each point 6 samples were made during 6 minutes and 5 seconds for each sample. The points were located to provide a homogeneous area to mensuration.

2.2 REVERBERATION TIME

To calculate the Reverberation Time, was used sound level meter type 2, model Sdb2+, from 01dB-Steel, in dBA scale, a chronometer accurately of hundredth of seconds, a video camera and a reference sound disk. The measurement points are shown in the figure 1.

In the sound system of each church, a frequency of 440 Hz was generated, during approximately 4 seconds and was measured the decline time of pressure sound level for 60 dB interval. Was used the video camera because we don't have the integration module for sound level meter. Therefore, with the images of the sound meter and chronometer during the declining data acquisition, we could make the graph of the reverberation time for each church. Such graph was set up with the averages of each point measures.

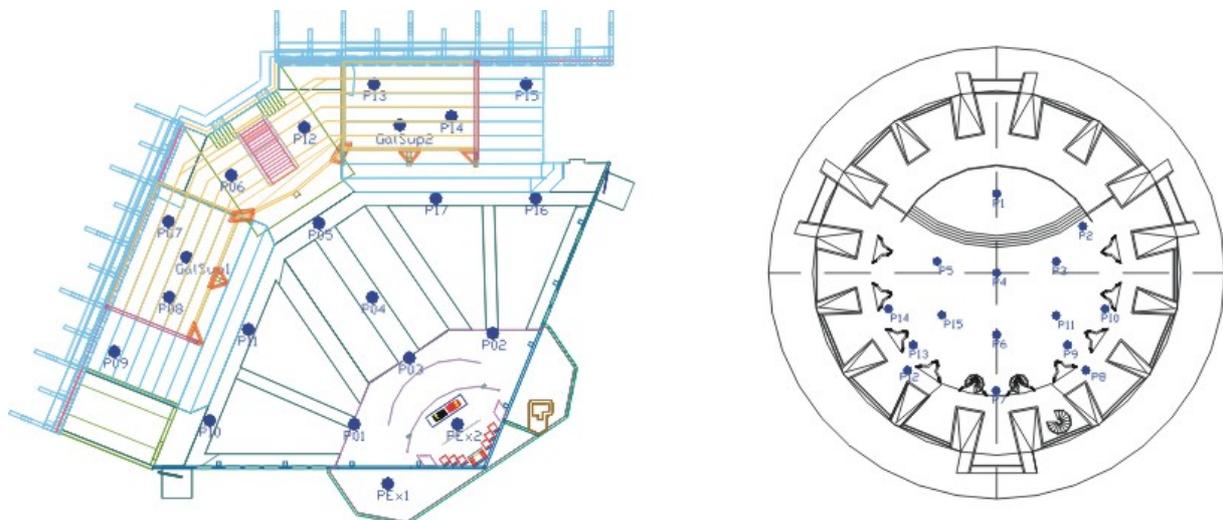


Figure 1 – Localization of the measurement points in the churches - Santa Maria Goretti and Our Lady of Glory Basilica, respectively.

3. RESULTS

The obtained data were analyzed by statistics and resulted in the following tables and graphics

3.1 MEASUREMENT OF SOUND LEVEL WITH OCTAVE 1/1 BAND FILTER

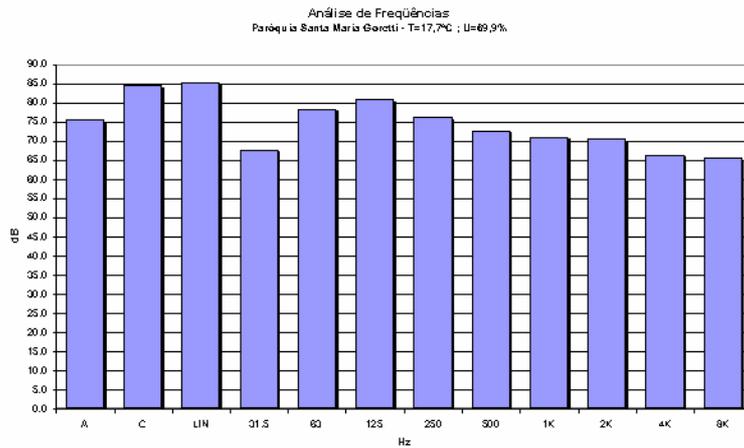


Figure 2 - Frequencies Santa Maria Goretti parish

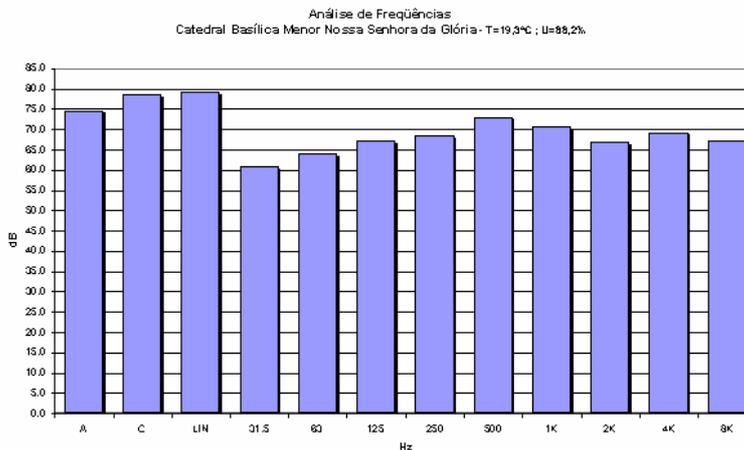


Figure 3 - Frequencies Our Lady of Glory Basilica

3.1 MEASUREMENT OF T-60'S REVERBERATION TIME

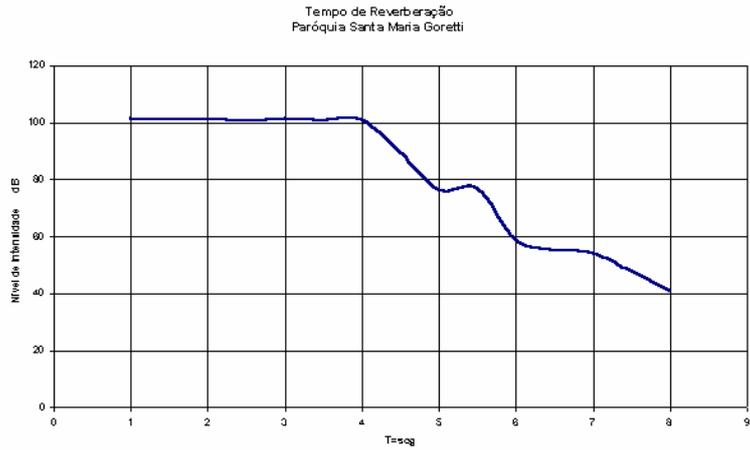


Figure 4 - Reverberation time from Santa Maria Goretti parish

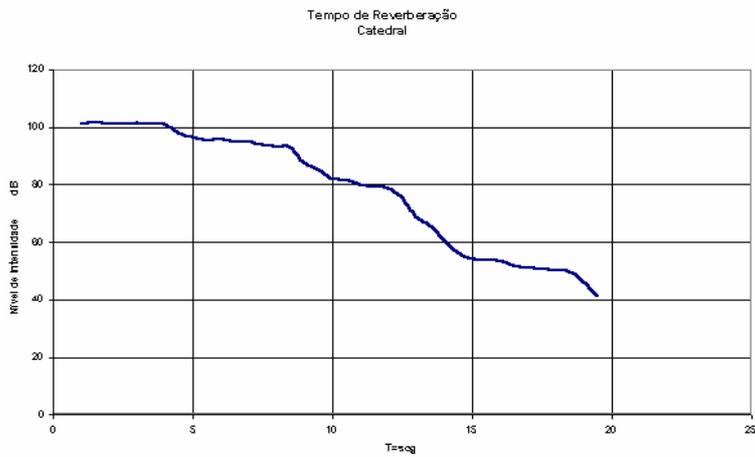


Figure 5 – Reverberation Time from Our Lady of Glory Basilica

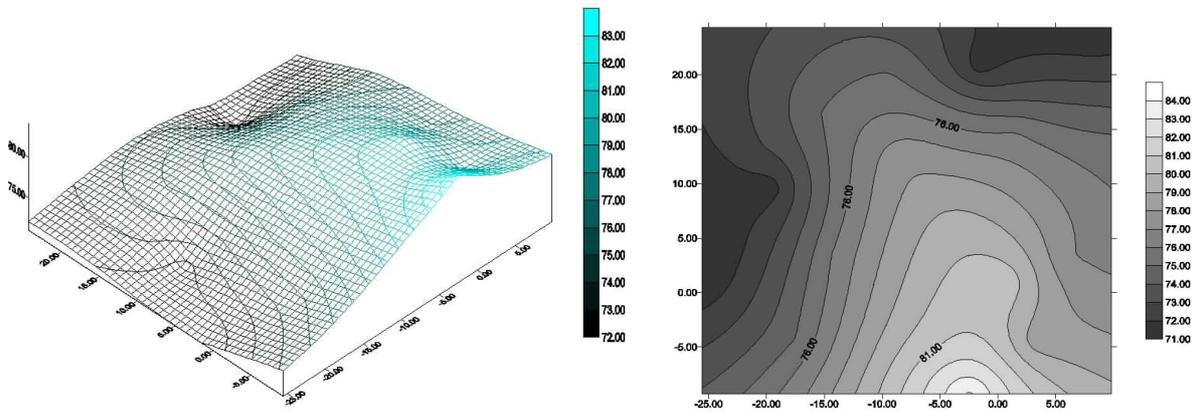


Figure 6 - Graphs 3D and 2D, respectively, SPL - Santa Maria Goretti

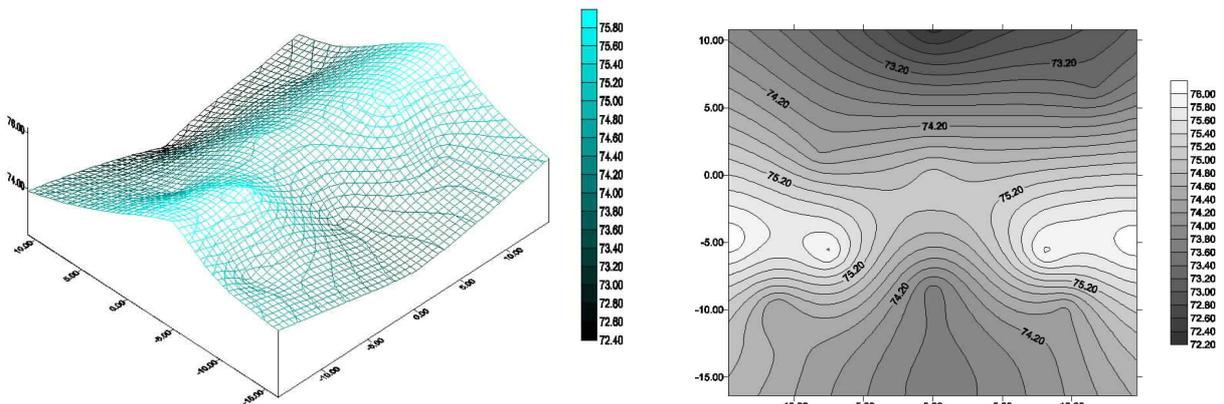


Figure 7 - Graphs 2D and 3D, respectively, SPL Our Lady of Glory Basilica

Table 1 – Statistical Study of Obtained Data in Santa Maria Goretti Parish

	Arithmetic Mean [dB]	Standard Deviation
A	75,47	3,683
C	84,55	2,850
LIN	85,12	2,454
31,5	67,61	1,889
63	78,38	2,113
125	80,91	3,384
250	76,10	3,837
500	72,70	4,175
1k	71,05	3,619
2k	70,58	3,416
4k	66,37	3,449
8k	65,47	3,668

Table 2 – *Statistical Study of Obtained Data in Our Lady of Glory Basilica*

	Arithmetic Mean [dB]	Standard Deviation
A	74,66	1,134
C	78,45	2,557
LIN	79,08	2,373
31,5	60,84	2,604
63	63,88	5,755
125	67,14	5,960
250	68,38	3,942
500	72,98	1,850
1k	70,58	1,399
2k	66,87	1,996
4k	69,19	1,542
8k	67,28	1,181

4. CONCLUSIONS

Based on the above information we can conclude: The reverberation of Santa Maria Goretti parish is inside of acceptable ranges, according to the literature [1]. It can be noticed that the sonorization system used strengthen the low frequencies and that the 500 Hz frequency is suggesting acoustic problems, or annulations, or wave superposition.

As for the Our Lady of Glory Basilica, the reverberation time is excessively high, causing discomfort to whom attend the masses/celebrations. It can be also noticed that the sonorization system used strengthen the medium frequencies and that the 125 Hz frequency is suggesting acoustic problems.

It is known that the low frequencies are attenuated through resounders or acoustical diffusers [2], but such apparatuses will only be economically viable to Santa Maria Goretti Parish, due to its architectural form. In the Our Lady of Glory Basilica, this solution becomes unviable due to its great height (82,0 m) and its conical form.

REFERENCES

- [1] P. Silva; *Acústica Arquitetônica & Condicionamento de Ar.* 4ª edição, Belo Horizonte, 2002.
- [2] F. A. Everest; *Master Handbook of Acoustics.* Fourth Edition, Califórnia, 2000.