Auralizing Auditoria in North Portugal: Two case studies

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Introduction

This paper deals mainly with auralization performed in two auditoria: one highly absorbent mainly for cinema presentations but also used for music concerts (CMM), the other much more reflective, mainly used for musical theatre performances (TeCA). Acoustical measurements and room acoustic simulation were used to evaluate the acoustical main parameters values and data was compared and related to geometrical and acoustical properties. By convolving anechoic recordings with measured and predicted impulse responses, auralization was performed to simulate the acoustical quality.

Auditoria Architectural properties

CMM is a recent and modern multipurpose Hall, geometrically fan shaped approximately 18 m long, 24 m wide and 11.5 m high. The main Hall has an average volume of 3000 m^3 and a seating capacity of 280 places on an acoustical seating area of 230m^2. The stage has a maximum volume of 1700 m^3 but its configuration can be adjusted, allowing different volumes. In this study, we used a minimum volume of 1300 m^3.

TeCA is an auditorium from late nineteenth century, recently reconstructed. Basically, the complete Hall is rectangular in plan, with an approximate volume of 7400 m^3. The main Hall has an average volume of 3000 m^3 and the audience area is variable since front audience has 152 movable seats distributed in 8 rows. In this study, only the first three rows were moved out and the hall capacity was 311 seats. All chairs are in wood, seat and front back medium upholstered except for the 72 special "high feet" seats at first and second balconies, which are clearly less upholstered.

Auditoria constructive details

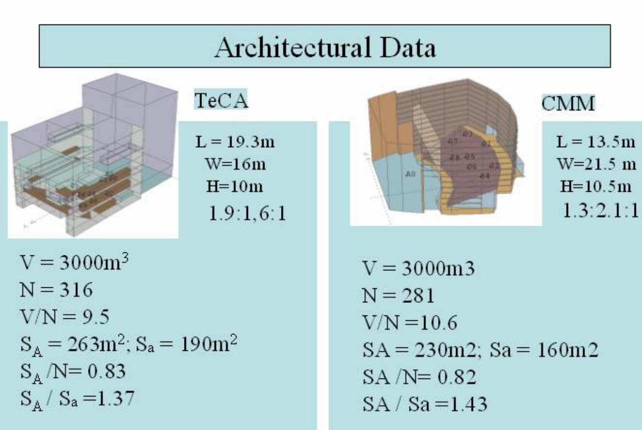

Figure 1: Geometrical data

Auditoria surface materials

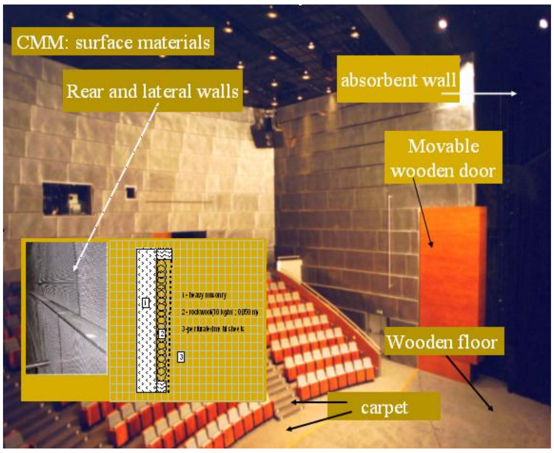

Figure 2: CMM surface materials

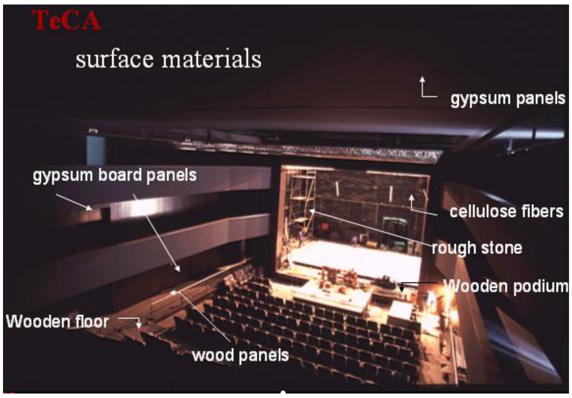

Figure 3: TeCA surface materials

Architectural data and details of the constructions of both auditoria are given in figure 1-3.

Technical procedures

To evaluate the interior acoustical properties of these auditoria, computer simulation and acoustical measurements were performed. We also predicted acoustical behaviour simulating the use of physical elements. For auralization in both auditoria, we use the technique of convolving anechoic recordings obtained from specialised audio libraries with measured and predicted impulse responses, with and without reflectors.

We had considered one omni directional sound source (A0) and a singer (A1) on stage and several receivers. Absorption data was obtained from literature [1, 2] and scattering coefficients were estimated from visual evaluation, following some guidelines from researchers on this subject.

For measurements we used swept sine and MLS signals emitted and post-processed by measuring software for audio, acoustics and vibrations [3].

Data Results

Predicted and measured data for both halls are given in table 1 and 2:

CMM Acoustical Parameters	Measured	Predicted
T_{mid} / s	1.03<T<1.13	0.96 <T<0.99
EDT / s	0.81 <EDT< 1.05	0.85<EDT< 1.44
D_{50} / %	72<D50≥ 85	$62<D_{50}< 83$
C_{80} / dB	7.4<C80> 10.6	$4.3< C_{80}< 8.2$
T_s / ms	$28.5 <T_s<45$	$36 <T_s< 45$

Table 1: Acoustical parameters for CMM

TeCA Acoustical Parameters	Measured	Predicted
T_{mid} / s	1.29<T<1.41	1.7 <T<1.8
EDT / s	1.2 <EDT< 1.4	1.1<EDT< 1.5
D_{50} / %	40<D50< 60	$45<D_{50}< 55$
C_{80} / dB	2<C80< 4	$2.5< C_{80}< 4$
T_s / ms	$65 <T_s<87$	$73 <T_s< 88$

Table 2: Acoustical parameters for TeCA

We simulate two symmetrical lateral reflectors (LR), an acoustic shell (AS), a canopy (C) and three overhead panels (OH) over audience area and we did some experiences arranging some of these elements.

Audience area mapping for CMM, with and without LR, shows important differences in C_{80} values (fig.4). These differences can also be observed for TeCA: In fig. 5 binaural impulse responses are shown for receiver position R5 which corresponds to that displayed in figure 4.

Auralizations

For checking the quality of auralizations based on room simulation data we first had to compare signals convolved with measured impulse responses with those convolved with the synthetic impulse responses which was generated by the room simulation software. The good coincidence of both sound impressions was the prerequisite for the validity of further comparisons of various details of room acoustical properties. In CMM e.g. these auralizations enabled a clear binaural impression of the efficiency of side reflectors for improving the sound quality for music in this highly absorbent room.

The binaural impression of additional reflections from the left side, for a receiver R5, in the left part of TeCA, is visible in figure 5: a strong new peak (arrow) in the impulse response confirms the subjective effect of a broadening of the apparent source width which could be perceived during listening via headphones.

Actors had complained about reflections from the side areas under the balconies when speaking on the proscenium. The simulation of side reflectors in the critical areas close to the stage could help optimizing their size and orientation by listening to the corresponding auralizations. These reflectors have already been realized and are appreciated by the actors today. Similarly the efficiency of the proposed reflectors AS, C and OH could subjectively be compared with the increase in the objective data D_{50} and C_{80}.

Conclusion

Auralizations prove to be a helpful tool for finding decisions for room acoustical improvements in both auditoria. The subjective impression can help to decide if the proposed solutions are effective and construction costs are worthwhile.

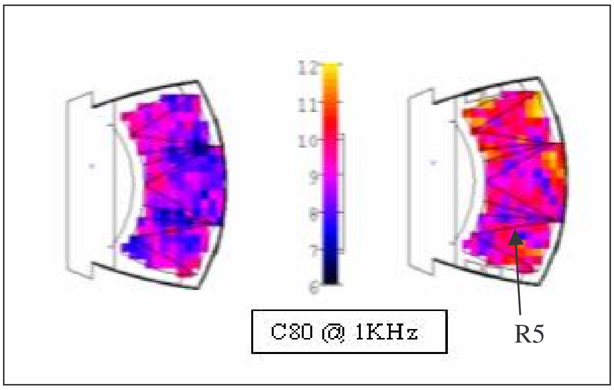

Figure 4: Audience area mapping (CMM)

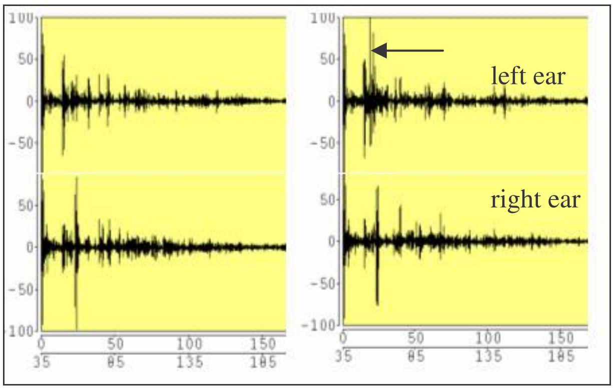

Figure 5: Binaural impulse response without (left) and with side reflectors in TeCA at position R5

References

[1] URL: http://www.Catt.se

[2] URL: http://www.ptb.de/de/org/1/17/173/datenbank.htm

[3] URL: http://www.winmls.com